ACCOUNTING INFORMATION SYSTEMS and Business Organizations

BARRY E. CUSHING
Associate Professor of Accounting
University of Texas at Austin

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Preface

The essential concept underlying this textbook is that today's accounting students require a basic knowledge of information systems and of their role in the performance of the accounting function in business organizations. Fundamental to this basic knowledge are: (1) an understanding of the patterns of flow of accounting data and information in business, (2) familiarity with the application of the principle of internal control, and (3) an understanding of the use of computers in current and future accounting information systems. The dramatic increase in use of computers in accounting information systems in the past two decades has left a void in available textual materials between (1) traditional presentations emphasizing accounting data processing in the context of manual systems and treating computers as a peripheral topic, and (2) general works on computers and management information systems with little or no coverage of accounting applications. This book attempts to integrate coverage of computer based systems with coverage of accounting applications. The intent is to provide a foundation for the development of today's accounting students into tomorrow's users, auditors, and managers of information systems.

This book is divided into four major sections. The first section, encompassing three chapters, explains and relates the concepts of management information system, accounting information system, organization, and control. The second section reviews the technology of information systems, and its application in business and accounting processes. This section includes coverage of small business machines and unit record equipment in Chapter 4, computer systems in Chapter 5, computer software and programming languages in Chapter 6, and real-time systems in Chapter 7. Also covered in this section are the essential tools of systems flowcharting in Chapter 5 and program flowcharting in Chapter 6. The third section, encompassing Chapters 8 through 11, traces the development of information systems, from analysis and design

through equipment acquisition, systems implementation, and systems management and control. This section covers the tools of work measurement, document flowcharting, feasibility analysis, PERT, long range planning for computer based systems, and the analysis and design of internal controls for computer systems.

The fourth section, encompassing Chapters 12 through 16, integrates the first three sections in illustrating the role of accounting information systems in the context of business organizations. This section discusses the information needs of the marketing, logistics, personnel, and finance functions in business and explains the accounting processes and data bases which help to fulfill those needs. Within each application area, manual, computerized batch processing, and real-time systems are developed and contrasted.

This book is intended for a one-semester course in accounting information systems for advanced undergraduate accounting majors or others interested in business applications of computers. Introductory financial and managerial accounting courses are a necessary prerequisite, and an introductory course in data processing which covers a computer language is helpful. The book should also serve as a useful supplement to graduate or advanced undergraduate courses in management information systems.

At the end of each chapter are problem materials divided into three categories, (1) review questions, (2) discussion questions, and (3) problems and cases. The review questions are intended to provide students with a tool for comprehensive review of their understanding of the material covered in the chapter. The sequence of topic coverage in the review questions corresponds almost exactly to the sequence of topic coverage in the chapter, which should facilitate student review. Questions in this category are not intended for assignment as homework. The discussion questions generally have no "correct" answer, and are intended to generate class discussion relating to the ideas covered in the chapter. The problems and cases are intended for homework assignment, and provide quasi-realistic situations for application of the concepts and techniques presented in the chapter. A solutions manual is available which contains solutions to the discussion questions and problems and cases only.

I wish to express my appreciation to Professors George Scott, Allen Bizzell, and Gene Sauls, whose classroom testing of earlier drafts of this book generated many useful suggestions for improvement. I am also indebted to several former graduate students who contributed in various ways to the development of the book, including David Dial, Tom Cook, Don Durflinger, David Palit, and Gary Pennington. Also deserving of thanks are the many students who have contributed to the development of the book by taking the classes in which it was tested. I also appreciate the assistance of the staff of Addison-Wesley and the several professors who reviewed earlier drafts and

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B.E.C.

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PART ONE

CONCEPTUAL FOUNDATIONS OF ACCOUNTING INFORMATION SYSTEMS

Chapter 1

Accounting Information Systems: An Overview

Accounting information is essential to the efficient management of economic affairs. Within a business organization accounting information is produced by a system. Most readers are probably familiar with many of the elements of such systems. These elements include journals, ledgers, and other records. They include people who carry out the procedures necessary to the operation of the system. And increasingly they include machines designed to relieve people of the burden of routine and repetitive tasks. The purpose of this book is to develop an understanding of these accounting information systems – of the elements they contain, of the ways in which they are designed, and of the role they play in supplying information to those who require it, both within and outside the business organization.

THE ROLE OF THE ACCOUNTING INFORMATION SYSTEM

The modern business organization served by the accounting information system is a very complex institution. Such an organization may employ thousands of people in tasks ranging from the development and engineering of new products to the management of a large force of salesmen. Its position of prominence in the modern world generates interest in its activities among many segments of society. Those groups which are most directly interested include its customers, suppliers, employees, lenders, stockholders, and the various governments under whose jurisdiction it operates.

How can the modern business organization plan, coordinate and control the multitude of activities which it undertakes? How can it supply information to the many people and institutions which are interested in its activities? The accounting information system plays a vital role in accomplishing these tasks. Figure 1.1 exhibits the relationship of the accounting information system to the business organization and to the environment (indicated by the large "E") of which the business organization is a part. Several aspects of this diagram will be referred to at various points in this section.

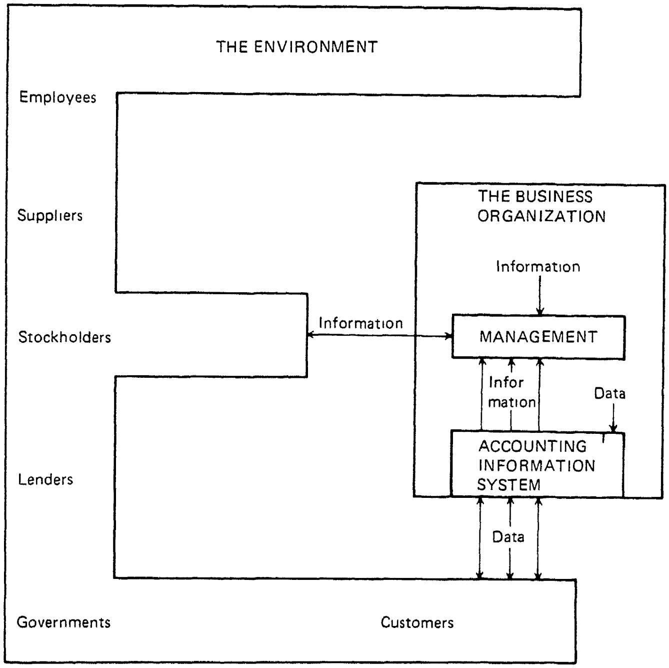

Fig. 1.1 Relationship of the accounting information system to the business organization and its environment.

It is useful to examine accounting information systems from the viewpoint of the users of accounting information, who utilize it as a basis for making decisions. There are two basic categories of such users: those external to the business organization, and those internal (management). External users are many and varied. Their needs are met to some extent by the publication of general purpose financial statements, such as the income statement and balance sheet. The subset of accounting which is concerned with the information needs of external users is known as *financial accounting.*

Internal users are also many and varied, but their needs for information do reflect a common objective, which is to maximize the economic well-being of the business organization in society. *Management accounting* is the subset of accounting which is concerned with internal information needs, and with how such information should be put to use. The accounting information system serves both external and internal users of information.

External Information Requirements

Six major external interest groups which receive information from the business organization are indicated in Fig. 1.1. The information each group receives in-

cludes both information for decision making and routine data concerning the execution of transactions. The six groups, and some examples of their information needs, are:

Customers. In this era of market orientation the customers of the business organization are perhaps the most important of the external interest groups. The requirements of customers include information regarding the products of the business such as: their prices, their features, where and how they can be purchased, and their guarantees and related servicing arrangements. These requirements are met through a combination of advertising, publication of catalogs and price lists, and communications by sales representatives. Customers may often obtain some product information, such as the reputation of the product for reliability and quality performance, from sources external to the business itself.

Routine information required by the customers of a business organization includes billing data, which is typically included on the document of sale prepared as a record of the transaction. Credit customers also require periodic information concerning the status of their accounts, including the amount owed, the discount available, and the date payment is due. These routine information requirements are met by the accounting information system.

Suppliers. The typical business entity purchases its inventories of raw materials or salable goods from a large variety of sources. If the business entity makes its purchases on credit (and most do), its suppliers require information concerning its reliability, credit standing, and ability to pay. A supplier typically obtains such information partly from external sources, such as credit rating agencies, and partly from the accounting information system of the business entity itself.

In the exchange between a business entity and its supplier, the supplier also requires certain routine transaction documents. The first of these is the purchase order, which indicates the items, quantities, and special features required by the business placing the order. If the goods are not acceptable to the business entity, information must be exchanged concerning possible adjustments in sale terms or the return of the goods. Finally, the business entity will provide payment for the goods, accompanied by supporting transaction documents. Much of this routine transaction data is furnished by the accounting information system.

Stockholders. A company's stockholders are vitally interested in all phases of its operations. They wish to evaluate its past performance and predict its future performance. The publication of annual financial statements is perhaps the single most important means of meeting these requirements. Quarterly financial reports are also becoming an increasingly important form of management reporting to stockholders. Providing such reports to stockholders is often referred to as the *stewardship function* and has traditionally been the responsibility of the accounting information system. Stockholders often obtain additional information regarding the business entity from external sources, such as

securities analysts and financial publications. Also required by stockholders is certain routine information concerning the execution of their stock transactions and the receipt of dividend payments. These routine information requirements are often met by the accounting information system.

Employees. As a group, employees are interested in certain general information regarding the business entity. This includes financial information, such as average wage levels, fringe benefit costs, and profits. It also includes nonfinancial information, such as levels of employment and productivity. Labor unions often represent the employee group in obtaining this information. Much of this information is provided by the accounting information system.

As individuals, employees expect periodic receipt of wages and salaries, accompanied by detailed information concerning deductions for income taxes, social security, insurance, union dues, etc. In the day-to-day performance of their job, employees often must refer to manuals to obtain information concerning how a certain aspect of their job should be performed, or what is company policy in a particular situation. The accounting information system is usually responsible for providing much of this routine information.

Lenders. Financial institutions which supply the business entity with capital for investment or expansion are very much interested in such factors as the reputation and ability of the company's management, its ability to meet its financial obligations, and its prospects for future success. A company's financial statements are an important source of information in this regard. Perhaps more so than other groups, lenders will also rely on outside sources for their information. The need of lenders for routine information concerning lending transactions requires an interchange of information with the accounting information system of the borrowing entity.

Governments. Many various agencies of federal, state, and local governments require information concerning the business entity. The Internal Revenue Service requires information concerning the company's profits and the amount of taxes that the company owes to the government. The I.R.S. also requires information about the amount of employee taxes withheld. The Social Security Administration requires information concerning the amount of wages earned and social security taxes withheld. If the company is in a regulated industry, such as railroads or insurance, one or more federal or state agencies is likely to desire information about its operations. If the company has international operations, many foreign governments may desire information about its activities in their countries. The requirements of governments are perhaps the most varied of all external reporting requirements faced by the business organization. The accounting information system plays an important role in satisfying such requirements.

The above list includes the major groups which desire information about the business entity. Many other groups also desire such information. These may include: (1) credit agencies, such as Dun & Bradstreet, which publish in-

formation about a company's credit standing; (2) industry and trade associations, which publish information about a particular industry; (3) competitors, which, of course, are interested in a company's pricing policies and its profitability; (4) the community of which the business organization is a part; (5) financial analysts, who advise clients interested in making investments; or (6) private citizens who are simply interested in some aspect of the company's activities.

For the most part, the information supplied to external users is either "mandatory" or "essential." Examples of information which it is mandatory to report include reports to governments on taxable income and tax withholdings, and financial statements, which must be issued to stockholders by all publicly traded corporations. Examples of information which it is essential to furnish include product information and billings to customers, and credit capacity information to lenders. The necessity for reporting information of this type places certain constraints upon accounting information systems which will be discussed later in this chapter.

As shown in Fig. 1.1, much of the routine data provided to external parties by the business organization is channeled through the accounting information system. In turn, the accounting information system also receives much routine data from these exchanges. However, note that the information for decision making which is provided to external parties is shown to be provided directly by management, rather than by the accounting information system. This reflects the fact that the ultimate responsibility for the fairness and accuracy of any information reported by the business upon which external parties base their decisions rests with management. This is true even though the accounting information system may serve as the actual channel for reporting this information.

Internal Information Requirements

In sharp contrast to external information requirements, information reported internally is "discretionary." This means that choices must be made regarding what information should be made available, to whom, how frequently, and so forth. Primarily because of this fact the area of internal information presents a much greater challenge to those who design accounting information systems than the external reporting area. In meeting mandatory and essential information requirements, the primary consideration is to minimize costs while meeting minimum standards of reliability and usefulness. When the reporting of information is discretionary, the primary consideration is that the benefit obtained from each report exceed the cost of supplying it. Much of the challenge in designing an information system is due to the fact that it is often very difficult to measure the benefit derived from reporting a given set of information.

All of the various levels of management in a business organization, from top management which is responsible for achieving overall company goals, to the operating management responsible for achieving the specific objectives of a

single operating department, require information in the performance of their duties. As indicated in Fig. 1.1 the accounting information system is a major source, but not the only source, of information to management. The general business environment is an important source of information on such matters as economic conditions, new technologies, legal constraints, and market standing. Other sources within the organization provide information concerning such factors as the success of research and development projects, the morale of employees, and the level of worker productivity.

While the accounting information system is the primary "formal" information system in most organizations, there are many other formal, as well as "informal," channels of information. A formal information system is one to which an explicit responsibility for information production has been assigned. In contrast, an informal information channel is one which simply arises out of a need unsatisfied by a formal channel, rather than being created by a formal assignment of responsibility. The "grapevine" is a familiar example of an informal channel of information common to all organizations. As organizations grow in size, it is natural for some informal channels to become formalized.

As shown in Fig. 1.1 the accounting information system receives data not only from sources outside the business, but also from internal sources. For example, product cost information in a manufacturing firm is generated from data on materials usage, labor usage, etc. which are collected within the factory. The accounting information system prepares information for management by performing certain operations on all of the source data which it receives. The management of the business organization receives this information and utilizes it as a basis for decision making. Management decisions in turn affect the internal operation of the business organization, including the accounting information system, and also affect the relationship of the business organization with its environment.

Two major roles of accounting information in management decision making can be identified. First, accounting information often provides a stimulus for management decision making by indicating the existence of a situation requiring management action. For example, a cost report which indicates a large variance of actual costs over budgeted costs might stimulate management to take corrective action. Second, accounting information often provides a basis for choice among possible alternative actions. For example, accounting information is often used as a basis for setting prices or for choosing which capital assets to purchase. The importance of accounting information in this latter role is due to its contribution to the reduction of uncertainty regarding the merits of various alternatives.

Designers of accounting information systems must determine what the information requirements of management are and must respond quickly to changes in those requirements. The accounting system must be designed to meet these needs effectively. If management does not receive enough information, or receives poor information, its performance will not be as effective as it potentially could be. This could have an adverse effect on the entire organi-

zation. Thus, the accounting information system plays an important role in contributing to the effectiveness of the business organization.

ANALYSIS OF THE ACCOUNTING INFORMATION SYSTEM

Thus far the accounting information system has been examined as a "black box" – that is, its role in the business organization has been discussed, but the way in which it operates internally to perform that role has not. In this section the lid of the black box is lifted in order that its contents and the operations performed within it may be analyzed. The objective is to formulate a precise definition of what is meant by the term accounting information system.

Many readers may already be more or less familiar with the concept of the management information system. Accounting information systems are closely related to management information systems, both conceptually and in the real world. It is worthwhile to define and explore the concept of management information systems as a prelude to developing an understanding of accounting information systems.

Management Information Systems

A *management information system* may be defined as the set of human and capital resources within an organization which is responsible for the collection and processing of data to produce information which is useful to all levels of management in planning and controlling the activities of the organization. To many people, the term implies a computer-based system, but the term encompasses noncomputer systems as well. All business organizations have a management information system, but such systems vary greatly in their level of sophistication.

A fuller understanding of the concept of a management information system can be obtained from a careful analysis of the above definition. Several of the concepts referred to in the definition will be examined in greater depth in the following sections.

Management planning and control. It is appropriate to begin by analyzing the major purpose of management information systems, which is to facilitate the process of management of an organization. As used here, the term management encompasses all levels of administration in an organization, from top management, responsible for the overall success or failure of the organization, to operating management, responsible for the day-to-day operation of a single department. Depending on the size of the organization, there may be one to several layers of management between these two extremes.

The basic functions of management are planning and control. Planning includes such activities as setting objectives, establishing policies, choosing subordinate managers, deciding on capital expenditures, and making decisions on products and their promotion. Control involves implementing policies, evaluating the performance of subordinates, and taking action to correct substandard

performance. Information of various kinds is required in the performance of all of these functions.

Data vs. information. As implied in the definition, a distinction is generally drawn between data and information. *Data* can be thought of as comprising any set of characters which is accepted as input to an information system and is stored and processed. *Information* refers to an output of data processing which is organized and meaningful to the person who receives it. For example, data concerning a sale may indicate who the salesman was. When a large number of such data elements is organized and analyzed, it may provide important information to a marketing director who is attempting to evaluate his sales force. The term "data processing system" is often used interchangeably with "information system."

Several categories of information can be distinguished in a business organization. The major categories are: (1) financial information, which concerns the flow of financial resources through the organization; (2) logistics information, which concerns the physical flow of inventories and resources within and through the organization; (3) personnel information, which concerns the people who work for the organization; and (4) marketing information, which concerns the markets for the organization's product and the means of serving those markets. Much information within a business organization overlaps into more than one of these categories.

The data processing cycle. It is useful to conceive of data processing activities in terms of a three stage process. The three stages are (1) input, (2) processing, and (3) output.

The input stage of the data processing cycle includes several activities, the most basic of which is the initial *recording* of data on source documents. Another input step is the *classifying* of data according to a predetermined system of classification (such as a chart of accounts). *Batching,* or the accumulation of similar inputs to be processed as a group, is another input activity. A fourth is *verification* of data, which involves checking its accuracy prior to submitting it for processing. Still another input activity is *scanning,* which involves searching for, and assimilating facts about, the business environment.

The processing stage also includes a variety of activities. One is the *sorting* of data, which involves arranging similar input items into some desired sequence. Another is *calculating,* which encompasses any form of mathematical manipulation. Comparing, or the simultaneous examination of two or more items of data as a basis for subsequent action, is another processing activity. Still another is *transcribing,* which involves transferring a set of data from one document or record to another. *Summarizing* is a very important processing activity, meaning the aggregation of bits of data into meaningful totals or condensations. Another is *filtration,* which is the screening out of extraneous data. *Indexing* is a processing activity which involves assigning codes to an item of data within a reference system in order to facilitate the retrieval of that data

for any of several purposes. Another processing activity, frequently last in chronological sequence, is the *storage* of data for future reference.

While the input and processing stages represent the means to an end, the output or communication stage is the end itself. This stage includes *reporting,* which is the formal presentation and distribution of processed data, usually in summary form. Another output activity is the *issuance* of documents, such as checks, invoices, and purchase orders, for use in other data processing activities or by external users. Another output activity is *retrieval,* which is the fetching of a specific item or items of stored information at the request of a system user. A fourth output activity is *analysis,* which encompasses all of the ways in which receivers of system output utilize it in decision making to achieve the organization's objectives.

It is important to note that most data do not have all of these activities performed upon them, and some data may not even pass through all three stages. For example, data from a transaction may be simply recorded and stored, perhaps never reaching the output stage. On the other hand, data on the plans of competitors may be obtained by scanning and used immediately in analysis without passing through any processing steps.

The study of information systems involves all of these stages of the data processing cycle. In contrast the general study of accounting or management often begins by assuming that certain information is given, and focuses on how the information should be used in decision making. The latter approach ignores many key factors in information systems design. For example, it ignores the problems of designing the information system to provide for: (1) collection and processing of data in the most efficient manner, (2) preparation of information that is accurate and reliable, (3) preparation of information in time to be useful to management, (4) data processing and information preparation at a cost less than the benefits derived, and (5) effective coordination of people and machines during the cycle of data processing. These and similar problems form the focal point of the study of information systems.

Information system resources. A management information system utilizes both human and capital resources, with the latter consisting primarily of data processing equipment. With reference to the relative utilization of these two types of resources, two basic categories of data processing systems can be distinguished: (1) manual data processing systems, in which the major share of the data processing load is carried by people; and (2) automated data processing (ADP) systems, in which the major share of the data processing workload is carried by machines. Within these two basic categories, several levels of sophistication are possible.

The lowest possible level of sophistication in data processing systems is a completely manual system, where people perform all data processing functions. Such systems are common among small, local businesses. In such businesses it may be that no single individual is assigned data processing functions, but instead such functions may be a secondary part of the responsibilities of several persons. The major advantages of people as data processors are their flexibility, or ability

to perform all of the various functions of a data processing system, and their judgment, or ability to adapt to unfamiliar situations. The major disadvantages of people are their slowness and lack of reliability.

Most manual data processing systems utilize one or more forms of special purpose business machines. The most common types of these machines include: (1) typewriters, which increase recording speed and legibility; (2) calculating machines, which increase speed and accuracy of calculation; (3) cash registers, which record, classify, and provide control over cash receipts; (4) duplicators, which conserve time in the making of duplicate copies of documents or reports; and (5) bookkeeping machines, which combine the features of a calculator and a typewriter. This is by no means a complete list of available types of business machines. In general, machines of this sort increase the speed and reliability of data processing in manual systems. They require constant interaction with people, and so do not undermine the advantages of people as data processors, but neither do they completely eliminate the disadvantages of people.

The lowest level of sophistication in automated data processing systems is that of the *punched card system.* Among the primary data processing functions performed by punched card equipment are recording (punching), sorting, calculating, summarizing, and reporting. Human intervention is required at the beginning and end of each processing step, but is minimized in between. Such systems therefore have much greater speed and reliability than manual systems, but sacrifice some degree of flexibility and adaptability. Also, due to the greater degree of formalization necessitated by automated systems, punched card systems require a more extensive initial design than do manual systems. Prior to the advent of computers, punched card systems for many years represented the highest level of automation in office equipment. However, as complete data processing systems, punched card systems have nearly been made obsolete in recent years by computer systems. Even so, punched card equipment is still quite commonly used as auxiliary equipment in computer systems.

A vast step higher in sophistication from punched card systems is the level of *electronic data processing* (EDP), or computer systems. Computers can perform many processing steps together in a series with no human intervention because of their ability to store and execute a set of instructions (called a *program).* Computer systems are much faster and more accurate than punched card systems because of their use of electronic, rather than electromechanical, components. However, computer systems also tend to be less flexible and adaptable than manual systems, and the extent of the initial design effort is often enormous. Available computer facilities have a wide range of capabilities, including differences in speed, storage capacity and other features. The pace of change in this area has been very fast in recent years, making this one of the most challenging aspects of the entire field of information systems.

The degree of mechanization required by an information system increases in direct proportion to the volume of data processing that the system must accomplish. It is useful to compare data processing systems conceptually in terms of cost per item processed. In manual systems the major components of pro-

cessing costs are variable, and so cost per item processed is relatively constant. This type of system is thus well suited to low-volume operations.

On the other hand, fixed costs of facilities represent the major costs in automated data processing systems. Because of this, cost per item processed declines as volume increases in an automated system, making this type of system well suited to high-volume operations. This concept is illustrated graphically in Fig. 1.2. The curves shown in the figure reflect relative values rather than actual figures. In a growing organization increased volume of data processing work represents one of the major pressures toward converting from a manual to an automated system.

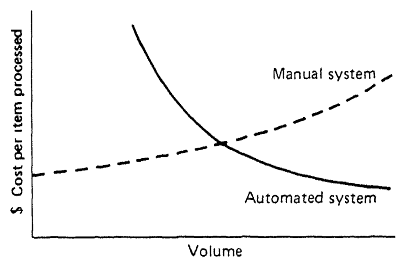

Fig. 1.2 Relationship of cost per item processed to volume in manual and automated data processing systems.

System. The final aspect of the definition of management information system to be discussed here is the concept of *system*. This is a word with many diverse meanings and implications. In its broadest and most abstract sense, a system is an entity consisting of two or more components or subsystems which interact to achieve a goal. Used in this sense the term could be applied to a community, a family unit, or a business organization. In a more specific sense, the term is used by specialists in the computer field to refer to either the equipment and program making up a complete computer installation, or a set of programs and related procedures for performing a single task or set of related tasks on a computer.

Closely related to this notion is the process known as *systems analysis,* which also has both abstract and specific meanings. In its most abstract sense, systems analysis refers to a rigorous and systematic approach to decision making, characterized by a comprehensive definition of available alternatives and an exhaustive analysis of the merits of each alternative as a basis for choice. The approach often involves attempts to quantify factors which would otherwise be considered on an intuitive basis and also frequently makes use of computers. The central theoretical principle of systems analysis is referred to as the *systems concept.* This principle directs that choices among alternative courses of action

within a system must be evaluated from the standpoint of the system as a whole, rather than from the standpoint of any single subsystem or set of subsystems.

When applied to information systems in complex organizations, one major effect of the systems concept has been to encourage *integration,* which refers to the combining of previously separated subsystems. Integration has made data processing more efficient by eliminating duplication of recording, storage, reporting, and other processing activities within an organization. For example, where it was formerly common in many businesses for the preparation of bills and the maintenance of accounts receivable records to be performed separately, these functions are often combined in a single operation in modern business organizations. Integration has been facilitated by the increased utilization of computers, which have tended to replace specialized clerks and thereby reduce the need for separate specialized subsystems.

In a more specific sense, the term systems analysis is used by computer professionals to refer to the process of designing computer applications. It is the step which immediately precedes the preparation of computer programs. A meaning of the term which dates back to precomputer times is that systems analysis is the process of designing procedures and selecting equipment for performing data processing functions in manual or punched card systems.

Accounting Information Systems – A Definition

Accounting information systems possess all of the characteristics of management information systems. They utilize the same kinds of resources and have a data processing cycle which produces information for management planning and control. The major difference is one of scope. The management information system encompasses all data entering the organization, all processing activities within the organization, and all information which is used by persons in the organization. The accounting information system is concerned only with certain types of data and information. Thus the accounting information system is a subsystem of the management information system within an organization.

It is possible to identify two types of management information with which accounting information systems are primarily involved. These are: (1) financial information, and (2) information generated from the processing of transaction data. While much management information actually falls into both of these categories, there is also much which fits one or the other, but not both, descriptions. For example, unit inventory or unit sales information is not financial, but is often produced from transaction processing. Similarly, budgets and capital investment analyses are representative of the kinds of financial information which are not generated directly from transaction processing. Figure 1.3 illustrates that these two types of information are subsets of management information, that they do overlap, but that neither is a complete subset of the other.

The accounting information system is the most pervasive and is also often the largest of the information subsystems in business organizations. It is per-

Purchasing of assets and services. The purchase of inventories, fixed assets, services, and supplies is one of the most basic business transactions of all business entities. This transaction could be considered the starting point of the entire business process. The transaction is represented by the following journal entry:

Purchases	XXX	
Fixed Assets	XXX	
Expenses (various accounts)	XXX	
Accounts Payable		XXX

The purchases account represents either the raw material inventory of a manufacturing concern, or the merchandise inventory of a retail or wholesale firm. The accounts involved in this transaction are summary accounts, and such an entry would usually represent a large volume of transactions. Individual inventory purchases might be recorded in a detailed inventory ledger by item number. Individual fixed asset purchases would be recorded in a fixed asset ledger, and expenses would be recorded in various expense ledgers. Each accounts payable entry would be posted to the appropriate vendor record in an accounts payable ledger. These detailed ledgers and transaction data may be used to generate many useful reports and analyses of expenses, inventories, vendor activity, and so forth.

Payroll. The payment of wages and salaries is another type of transaction which is very basic in most business entities. This transaction would be represented by the following journal entry:

Payroll	XXX	
Taxes Payable (various accounts)		XXX
Other Deductions		XXX
Cash		XXX

This entry is a summarization of tens, hundreds, or perhaps thousands of individual transactions with employees. Detailed records must be kept for each employee, primarily to fulfill tax requirements. The amount in the payroll account is distributed to various expense and inventory accounts. The payroll account is also frequently analyzed to prepare various detailed cost reports used for decision-making purposes.

Sale of products. The sale of a product is perhaps the most essential of the basic business transactions. This transaction can be represented by the following journal entry:

Accounts Receivable	XXX	
Cost of Goods Sold	XXX	
Sales		XXX
Finished Goods Inventory		XXX

Once again, this entry represents several detailed sets of records. A detailed accounts receivable ledger contains a record of the account of each individual cus-

tomer. Cost of goods sold may be analyzed in detail by inventory categories as a basis for planning the composition of future inventories. Sales may be analyzed by salesmen or by territory as a basis for evaluating the effectiveness of marketing effort.

Cash receipt and disbursement. Transactions involving the receipt and disbursement of cash are very important to all business entities. Receipt of cash usually initiates the following journal entry:

Cash	XXX	
Accounts Receivable		XXX

Disbursement of cash is reflected by the following entry:

Accounts Payable	XXX	
Cash		XXX

Such entries affect the detailed accounts receivable and accounts payable ledger records as well as the cash account. These detailed ledgers, and the transaction detail underlying these entries, may be used to generate many different reports, including cash flow analysis and projections and cash budgets.

Flow of inventory through production. This process is represented by two basic transactions, the first of which reflects the accumulation of all production costs:

Work in Process Inventory	XXX	
Raw Materials Inventory		XXX
Payroll		XXX
Manufacturing Overhead		XXX

and the second of which reflects the completion of production:

Finished Goods Inventory	XXX	
Work in Process Inventory		XXX

These transactions, of course, are peculiar to a special type of business organization — one which is engaged in manufacturing. They are also distinguished from those mentioned previously in that they are "internal" rather than "external" transactions, meaning that there is no outside party involved. These transactions reflect several detailed sets of inventory and production records and the data underlying the entries is used in the preparation of many various "cost accounting" reports.

The transactions outlined above represent the vast majority of all business transactions in terms of volume. Each of the entries shown typically summarizes hundreds or thousands of individual transactions. Of course there are many other various types of transactions with which an accounting system must cope, but none which are as basic in terms of volume. A major concern in the study of accounting information systems is the design of systems to perform these high-volume tasks efficiently and reliably.

Preparation of Financial Information

The design of accounting information systems should also concern itself with the preparation of financial information for management. As mentioned previously, much financial information is generated directly as a by-product of transaction processing. However, it is dangerous for management to rely solely on by-product information. In most businesses of medium to large size, management's needs for financial information go well beyond that which is generated from transaction processing.

For example, consider the planning function. Since transaction-generated information necessarily involves only the past, it is not by itself relevant in planning for the future. The budget is an important financial planning tool, as is capital expenditure analysis. Both of these techniques use transaction data to some extent, but must also rely upon financial forecasts. Financial information relating to the environment of the business firm is also important for planning purposes. Examples include price level and national income information as well as information on the prices and profitability of the products of competitors.

THE EVOLUTION OF ACCOUNTING INFORMATION SYSTEMS

The System Life Cycle

In a growing business organization, an information system undergoes a limited life cycle, from the point at which it is born to meet needs which had outgrown its predecessor system, to the point at which it is replaced because it is no longer adequate to meet the information needs of the business. Two factors have tended to shorten the life cycles of business and accounting systems in recent years: (1) the rapid growth of business organizations, and (2) rapid changes in information processing technology. The life cycle of information systems is examined here in three separate stages, (1) analysis and design, (2) implementation, and (3) operation.

Analysis and design. The analysis and design phase is equivalent to the gestation period of an information system. This stage begins with the recognition that the continuing growth of the organization is raising problems with which the old system may be unable to cope. This initiates an extensive survey of the existing system, and of current and future information processing needs. An analysis of the information obtained in the survey attempts to discover the major problem areas in the existing system. If the old system is a manual one, the feasibility of automation may be considered.

One of the most important steps in the analysis and design phase is the survey of information requirements. In accounting information systems, much of the data processing and information preparation is either mandatory or essential, particularly that done for external users. To the designer of an account-

ing information system, then, these mandatory and essential requirements are given and fixed. The designer faces the problem of determining the remaining information needs, primarily internal, which the system should fulfill. The next step is to determine the extent to which these internal information needs may be satisfied by information prepared as a by-product of the processing of mandatory and essential information. Any remaining information needs must be met with discretionary information, which will involve the systems designer in comparing the value of the information with the cost of enlarging the accounting information system to enable the information to be prepared.

Following the survey and analysis is a period of *synthesis,* in which a program of corrective action is developed. Such a program may entail only minor modification of the existing system, or perhaps complete replacement of the existing system with a more advanced system. Throughout this period each alternative is rigorously evaluaged in terms of its costs and benefits to the organization. If the program recommended in the synthesis is approved by management, work proceeds on the detailed systems design.

All aspects of the new system are considered in the detailed systems design, including personnel, hardware, procedures, and data flows. Almost any major systems project will involve some personnel problems, which must be planned for, such as employee displacement, relocation, hiring, and retraining. Also common are problems associated with equipment acquisition, such as selection of desired features, arranging for maintenance service, and financing the purchase. Procedures must be designed to assure efficiency and reliability of processing. In EDP systems many procedures must be programmed. Data flow problems include deciding on the content and arrangement of data on source documents, designing record layouts, establishing the content and organization of files, and determining the appropriate content, format, and distribution of reports.

Implementation. Once the detailed systems design is completed, the new system must be successfully implemented. If the new system is a major revision or replacement of the old, the first important step in this stage will be to plan and schedule the various implementation activities in order that they will be properly coordinated. Another step in implementation is to hire and train new employees, and relocate existing employees if necessary. In addition, new processing procedures must be tested and perhaps modified. New equipment must be installed and tested. Standards and controls for the new system must be established. Complete system *documentation,* consisting of descriptions of procedures, charts, instructions for employees, and other descriptive material, must be developed. When the new system is ready to begin functioning, it may be operated simultaneously with the old system for a brief period, with the output of the two systems being compared to assure that the new system has no major defects. The final step in this phase is the dismantling of the old system and complete conversion to the new.

Operation. After the new system has been operating on its own for a short while, follow-up studies are usually conducted to detect and correct the inevitable minor, and sometimes major, design deficiencies that were not apparent at the point of conversion. Throughout its lifetime the system will be subject to periodic review. Minor modifications may be made as problems arise or as new needs become evident. Eventually the reviews will indicate that major modification or replacement should be considered and the process will begin all over again.

The Accountant's Role in Systems Change

In most business organizations accountants will play a key role in this process of systems change. As mentioned previously, in some firms the accounting and information systems functions are one and the same, and so accountants would be directly responsible for performing systems work. In other firms accountants are at least one of the primary users of the information system, and so are vitally interested in how the system operates. It is always important for the users of an information system to become involved in its design.

In many smaller companies, the expertise necessary to analyze and design information systems may not be present within the company, and as a result reliance may have to be placed upon outside consultants. One of the main sources of such consultants is the public accounting profession. Many public accounting firms, particularly the larger ones, employ specialists in systems work in their "management advisory services" departments. Other major sources of consulting in the systems area are business machine manufacturers and management consultants not associated with public accounting.

FUTURE CHALLENGES TO ACCOUNTING INFORMATION SYSTEMS

Change is inevitable in society, and the pace of change in our modern society seems to be accelerating. Such change will bring new problems and new challenges to designers of accounting information systems. From trends that are visible in society today, it is possible to predict some of the major challenges of the next several years.

Social Responsibility in Business

One major trend of the present era is the demand by society that business organizations become more socially responsible. This trend is evident in several respects, including the consumer protection movement, legislation encouraging the hiring and training of members of socially disadvantaged groups, and perhaps most dramatically in the movement to save the environment. The business world is beginning to respond to these demands. Accounting information systems have a definite contribution to make here. There is a need for estimating the costs and benefits of proposed projects designed to improve the well-

being of society, in order to assist business management in deciding which such projects are worthwhile. While such projects are in operation, there is a need for information systems to process data on them and to provide business management with information which is useful in evaluating existing projects and planning future ones. There is a need to establish systems of internal control for such projects. These needs must be met before business can launch a truly effective effort in the direction of social responsibility.

Accounting for Human Assets

Another major trend of the present era is the growing importance of human knowledge and skill as a valuable economic resource. The initial development of modern accounting information systems took place early in the twentieth century. During this period, the most important assets were physical assets, such as cash, inventories, buildings, and machinery. The vast majority of the labor force was unskilled. Physical assets were thus the primary concern of accounting information systems.

In the modern age, human knowledge and skill is usually the primary factor in the success or failure of business organizations. Yet the accounting information systems of the present day do not reflect this fact. They still treat physical assets as being of primary importance, and all but ignore human assets.

The effective management of human assets requires information. It is the function of accounting information systems to provide such information. New methods of recording, classifying, and processing data concerning human resources must be developed. Methods of reporting information to management must be revised to incorporate the human factor, so that this factor will be given adequate consideration in management decisions. Systems of internal control for the human asset are needed. These needs clearly call for innovative thinking and action on the part of designers of accounting information systems.

Scientific Approaches to Management

A third major current trend is the movement toward more scientific approaches to management. The last two decades have seen the development of an entirely new discipline, commonly referred to as *management science* or *operations research*. This discipline approaches management decision making by attempting to construct mathematical models of real decision problems. Solutions to such models are then used in making the actual decisions. Practitioners of this discipline make liberal use of computers in building and solving mathematical models. The field is often considered as a branch of systems analysis.

Among the most important variables which operations researchers require in building models of business decision problems are measures of cost and benefit. However, when they attempt to obtain such measures from accounting information systems, they are often frustrated to find that the information is not in the form which they require. This is true because accounting systems

have never before had to concern themselves with providing inputs to operations research models.

The operations research approach has tremendous potential for generating better management decisions. The full realization of this potential requires that accounting information systems be structured to provide relevant and reliable inputs to operations research models. Designers of accounting information systems must study the common forms of operations research models in order to develop an understanding of the type of information that is needed. Changes in patterns of recording, classifying, and processing will be required.

The problems discussed in this section represent only a few of the major challenges in the field of accounting information systems today. Before the student can fully appreciate and respond to these future challenges, he must first develop an understanding of the present state of the art in accounting information systems. Toward this end, Part One of this text continues with a discussion in Chapters 2 and 3 of the subjects of organization and control, and their relationship to accounting information systems in business organizations. Part Two discusses the processing facilities available to designers of accounting information systems, with particular emphasis on computer facilities. Part Three covers the approaches and methods involved in conducting a systems investigation. Part Four seeks to develop an understanding of the primary uses to which accounting information is put in the management of the marketing, logistics, personnel, and finance functions in the modern business organization.

REVIEW QUESTIONS

1. Define the following terms:

financial accounting	systems analysis (three meanings)
management accounting	systems concept
stewardship function	integration
management information system	accounting information system
data	file
information	record
punched card system	synthesis
electronic data processing	documentation
program	management science
system (three meanings)	operations research

2. What are two major categories of users of accounting information? What are the major user groups within each category, and what is the nature of their information needs?

3. From what sources other than the accounting information system does management receive information?

4. Distinguish between "mandatory," "essential," and "discretionary" reporting of information and give an example of each.
5. Distinguish between "formal" and "informal" information systems and give an example of each.
6. Identify two major roles of accounting information in management decision making.
7. The two basic management functions are assumed to be planning and control. What are some of the specific activities involved in each of these functions?
8. Identify and describe four major categories of information in a business organization.
9. Identify the three major stages of the data processing cycle, and indicate the major activities in each stage. Relate the data processing cycle to the double entry accounting process.
10. Identify two basic categories of data processing systems. Within each category describe the various levels of sophistication in data processing facilities which are available to the information systems designer.
11. What are the advantages and disadvantages of people as data processors? As a data processing system becomes more automated, what effect is there on these factors?
12. What are some of the common types of special purpose business machines?
13. How do manual and automated data processing systems compare in terms of cost per item processed? What pressures does this create as the volume of data processing work in an organization becomes larger?
14. How are accounting information systems distinguished from management information systems?
15. What are some of the basic transactions of a business organization? Can you give the journal entries for these transactions?
16. Why is it dangerous for management to rely solely on information generated as a by-product of transaction processing in meeting its needs for financial information? What are some examples of financial information which is not generated from transaction processing?
17. What are the three major stages in the life cycle of an information system? What activities are performed in each stage?
18. Discuss the role of accountants in the process of systems change.
19. What are three contemporary social trends which present challenges to the designers of accounting information systems?

DISCUSSION QUESTIONS

20. Should an accounting information system be structured to meet the needs of external or internal users? To what extent are these two categories of needs similar, and to what extent do they differ?
21. To what extent would you expect the information systems of nonprofit organizations or governments to differ from those of business organizations? To what extent would you expect to find similarities?
22. To what extent do general purpose financial statements meet the needs for information about the business organization of its customers? of its suppliers? of its stockholders? of its employees? of its lenders? of governments?
23. When a business undertakes projects to improve the well-being of society, how can it measure the benefits of such projects in order to evaluate their relative worth?
24. Suppose a business wished to record its human assets on its balance sheet. How could it assign asset values to them?

PROBLEMS AND CASES

25. In this chapter several of the highest volume transactions of a typical manufacturing company were discussed, and corresponding accounting journal entries were illustrated.
    a) List several of the highest volume transactions of a typical life insurance company and give the corresponding journal entries.
    b) List several of the highest volume transactions of a typical banking institution and give the corresponding journal entries.
    c) List several of the highest volume transactions of a typical management consulting or similar service organization and give the corresponding journal entries.
26. You are a payroll clerk responsible for the manual preparation of the employee payroll each week for a small firm having about 150 employees. Each Monday you receive from each department head or foreman a list of the hours worked by each employee in their department for the previous week. You must determine the gross pay, net pay, and payroll deductions for each employee. You utilize a series of tax withholding tables to help determine the amount of social security and income tax withholding. You also utilize, and update each week, a payroll master file which contains for each employee such data as his identification number, pay rate, the number of tax exemptions claimed, and year-to-date totals of gross pay, net pay, and all deductions. You must prepare each employee's paycheck, and also a report listing each employee and his hours worked, gross pay, net pay, and deductions for the week. Consider the activities in the data processing cycle as described in this chapter. For as many of these activities as possible, give an example from the process described above.

27. a) List in the appropriate order the journal entries reflecting the movement of inventory through a manufacturing firm.
    b) Which of these entries represent internal transactions and which represent external transaction?
    c) Which of the accounts included in your journal entries would normally be summary accounts representing a large number of subsidiary ledger records?

28. Katie Kimball has decided to go into the florist business under the name of Katie's Flower Shop. She has made arrangements to lease a downtown store and to purchase a delivery truck. One full-time employee has been hired to help Katie in the shop with preparing floral arrangements, waiting on customers, keeping records, and so forth. Katie expects to hire two part-time delivery boys.

    There are three wholesale florists in the area whom Katie expects to use as a source of supply. In the florist business, a wide variety of flowers and plants must be kept in stock, but the product is perishable. Intelligent buying and inventory control is a major factor in the success of a florist. Knowledge of seasonal trends is very important.

    Katie expects that a good majority of her sales will be made over the telephone, and will be on account rather than for cash. Collection of accounts is also likely to be a significant problem for a florist.

    Katie has come to you for assistance in designing an accounting information system for her business. Required:

    a) Design a document for the recording of sale transactions.
    b) Design a set of records, procedures, and reports to enable Katie to obtain up-to-date information on unpaid customer accounts.
    c) Design a set of records, procedures, and reports to provide Katie with the information she needs to properly manage her inventories.
    d) Design a set of records and procedures to enable Katie to maintain control of cash receipts and disbursements and to prepare monthly financial statements.

Chapter 2

Organization and Accounting Information Systems

The distribution of authority and responsibility within an entity is indicated by its organizational structure. An understanding of the patterns of authority and responsibility distribution is essential to the assessment of information needs within an organization. In turn, information needs define the required structure of data collection and processing activities within the accounting information system. Therefore, the structure of data collection, processing, and reporting activities within an accounting information system must closely parallel the organizational structure of the entity it serves. An understanding of the concepts of organization thus provides part of the foundation for the study of accounting information systems.

Knowledge of organizational concepts and practices is also important to the study of accounting information systems in another sense. Authority and responsibility must be distributed within the accounting information system itself in a manner which provides for efficient performance of functions and effective control of operations. For example, it is necessary to separate responsibility for certain key functions within the accounting information system in order to minimize the possibility of misappropriation of cash or other assets accompanied by falsification of accounting records. This separation of functions is often referred to as *organizational independence.* However, the study of this and other principles of organization within the accounting information system is complicated by recent advances in information technology, which have had profound impact upon patterns of organization of all information processing activities within business entities. Therefore another section of the foundation of understanding of accounting information systems is provided by a review of principles and trends of organization within such systems.

INTRODUCTION TO CONCEPTS OF ORGANIZATION

Organization may be defined as the way in which the activities of people are coordinated to achieve a goal. In large complex organizations, the goal is usually

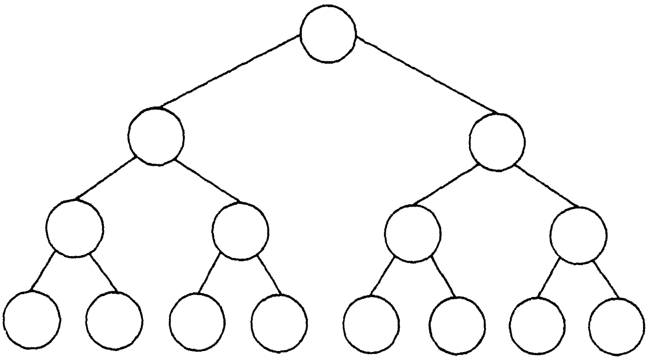

Fig. 2.1 An hierarchical structure.

divided into several subgoals, each of which is assigned to various subunits of the organization. Each subgoal may be further subdivided into still smaller subgoals, and so on down to the lowest levels of the organizational structure. This pattern of subdividing organizational goals and tasks into a graded series of lower level goals and tasks is called a *hierarchical* structure of organization. A simple example of a organizational hierarchy is illustrated in Fig. 2.1.

In Fig. 2.1 each small circle represents an organizational unit having a goal or subgoal and a manager responsible for achieving the goal or subgoal. Each line between two small circles represents a relationship between a subordinate manager and his superior. This relationship reflects the assignment of a subgoal to the subordinate by his superior. This must be accompanied by the delegation to the subordinate of the superior's authority to direct the operations of the lower level unit toward the accomplishment of its assigned subgoal. Acccep-tance of this authority by the subordinate creates for him a responsibility to manage his operation in a manner which will result in the achievement of the assigned subgoal. This is accompanied by a responsibility to report results to the superior. A subordinate may divide his assigned subgoal into still smaller subgoals, and delegate the authority for achieving these to other persons, who become responsible to him. However, a manager cannot delegate his responsibility – that is, he does not escape responsibility for achievement of his assigned subgoal, even though he may delegate a portion of his authority.

An organization is partially described by its number of *levels of supervision* and average *span of control*. The number of levels of supervision is simply the number of ranks between the highest level and lowest level units of the organization. Span of control refers to the number of subordinates reporting to a superior. For example, in Fig. 2.1 there are four levels of supervision, and the average span of control of each manager is two.

An organization is also partly described by the degree of centralization or decentralization of authority among its management levels. In a highly central-

ized organization, authority is concentrated at the higher management levels, with lower levels possessing a minimum of decision-making power. In a highly decentralized organization, a significant amount of decision-making authority may be delegated to lower levels. The concept is relative, and most organizations fall well within the two extremes. Even within the same organization, authority may be highly centralized in one functional area, such as production, and highly decentralized in other functional areas.

Problems of Modern Organizations

According to Whisler,[1] the four most prominent problems of modern organizations which have implications for information systems are: (1) rigidity, (2) information failures, (3) suboptimization, and (4) individual motivation.

Rigidity refers to a tendency within organizations to resist change. This problem has definite implications for informations systems in particular. In the past several years improvements in information technology have accelerated. Organizations have been and continue to be faced with the problems of adopting these new technologies in a manner which obtains the maximum advantage from their expanded capabilities. Rigidity has tended to aggravate the organizational problems of transition to new information technologies. Some specific examples of such problems are discussed later in this chapter.

The problem of information failures refers to failures in communication between organizational units due to their physical separation and specialization of functions. Messages to be communicated may be lost in transit, may be inaccurate or distorted, or may be vague or unclear. Information channels may become overloaded, causing delay or loss of information. This set of related problems has direct implications for the design of information systems. As organizations grow and functions become more separated and specialized, systems designers must identify problems of information failure as they arise and must design information systems in a manner which minimizes these problems.

Suboptimization is a term which refers to the problem whereby an organizational subunit, by attempting to optimize in the accomplishment of its assigned subgoal, makes it more difficult for the organization as a whole to optimally achieve its collective goals. This problem may be caused by the ineffective decomposition of goals into subgoals, but it is primarily a problem of coordination of operations among the various units within an organization. Since the accurate and timely reporting of information is essential to coordination, it is obvious that the problem of suboptimization also has direct implications for designers of information systems. Modern computer systems, if properly implemented, have great potential for improving the degree of coordination within large organizations, thus reducing the magnitude of the problem of suboptimization.

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[1]Thomas L. Whisler, *Information Technology and Organizational Change* (Belmont, California: Wadsworth Publishing Company, Inc., 1970), pp. 20-23.

The problem of individual motivation refers to the areas of conflict between individual goals and organizational goals. This problem is often aggravated by attempts to implement new information technologies. Designers of information systems may be able to relieve this problem to some extent by inco porating motivational factors into their designs.

Business Organization

Thus far the discussion of organizational concepts has been general, applying to all types of organizations. At this point, the discussion turns to business entities and attempts to relate general organizational concepts to the specific problems and practices of business organizations.

Business organizations generally interpret their primary goal to be the maximization of long run profits. Most businesses whose operations are similar follow common patterns of division of this goal into subgoals. For example, in a manufacturing business, the major subunits and their subgoals are likely to be: (1) marketing, with the goal of maximizing sales revenue; (2) production, with the goal of minimizing the production cost per unit; (3) finance, with the goal of providing the resources required for operation of the business at a minimum of expense; and (4) accounting, with the goal of measuring the success of the organization in achieving its goals. These goals may be broken down still further into additional sets of subgoals, assigned to lower level units, and so on. For example, the finance function could be further divided into the subunits of: (a) investor relations, with the goal of maintaining good relations with the firm's sources of long-term debt and equity funds; (b) credit and collections, with the goal of establishing and enforcing credit policies which will maximize the excess of sales revenue over bad debt losses; and perhaps (c) insurance, with the goal of optimum management of the risk of loss of resources by the firm. This is an example of how the efficiencies of specialization may be achieved by means of the hierarchical structure of organizations.

A familiar means of illustrating patterns of authority delegation in an organization is the organization chart. A sample organization chart for a typical large, single-plant manufacturing company appears in Fig. 2.2. This chart will be used as a point of reference for much of the discussion in the remainder of this chapter.

Many of the concepts discussed thus far are reflected in Fig. 2.2. Each box represents an organizational unit supervised by a manager. Each line connecting a manager to a lower level manager represents the delegation of authority to a subordinate and the corresponding responsibility of the subordinate to report to his superior. A manager is responsible for all the activities which appear under his span of control on the chart, that is, for the performance of all managers to whom a portion of his authority has been delegated. The hierarchical structure of the organization is clearly apparent.

In addition to the four functional areas mentioned above, Fig. 2.2 also shows two other functional areas at the top management level. The personnel function traditionally has been under the authority of the manufacturing vice

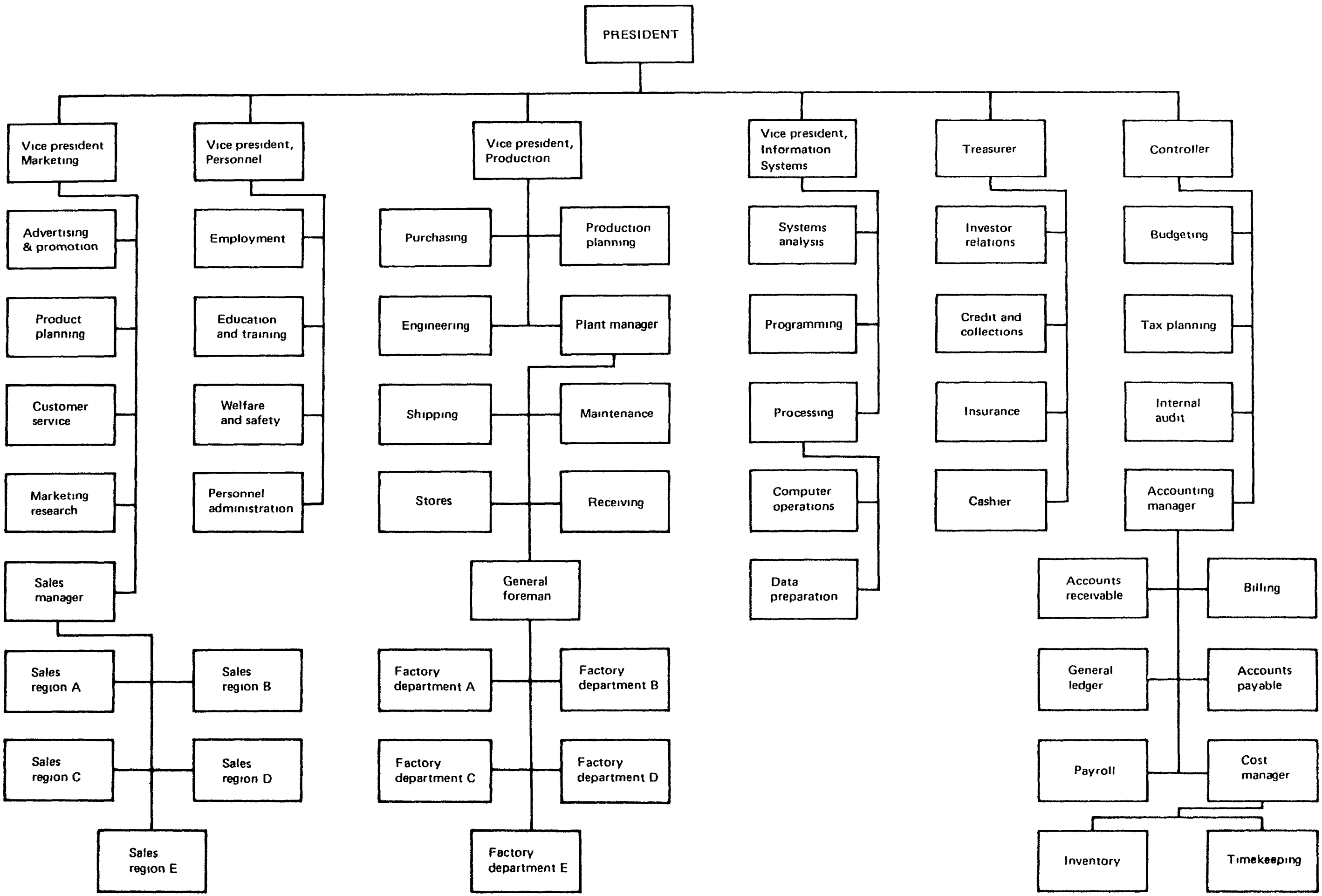

Fig. 2.2 A sample organization chart.

president, but many firms have elevated the personnel manager to the vice presidential level, reflecting the increasing importance of this activity to successul business operations.

In a similar vein, the information systems function has traditionally been part of the accounting activity. However, the evolution of computer technology has greatly expanded information producing capabilities. Many organizations have taken advantage of this added capability to establish an information function responsible for supplying reports and information to all other functional areas. Other organizations have had success in locating responsibility for the computer under the controller, or sometimes within one of the other functional areas. Whatever its organizational location, the computer relieves the accounting function of much of its routine processing tasks, allowing more attention to be given to designing new processing applications, interpreting reports, providing advisory services to management and other functional areas, and so forth. This subject is discussed more fully later in this chapter.

As mentioned, Fig. 2.2 represents a single-plant operation. In a large business organization having several plants, the problem of establishing the degree of centralization of authority within the organization becomes increasingly significant. A large business organization in which authority is highly centralized can more effectively coordinate the operations of its several plants, and thus avoid some problems of suboptimization. However, a business organization in which authority is decentralized often has fewer problems relating to motivation of managers at the plant level. Furthermore, the reporting of control information from individual plants to a corporate headquarters group is highly subject to the problem of information failures. This also favors decentralization of authority, since the information provided to corporate headquarters could be of poor quality and lead to bad decisions. However, modern information technology, by reducing information failures and facilitating control, provides a better basis for a policy of centralization.

Examples of suboptimization in business organizations are not uncommon. In large business entities it is difficult to subdivide the profit maximization goal into an appropriate set of subgoals. This may create situations of *goal conflict,* where a given decision or action will have contrary effects on the achievement of two or more subgoals. For example, the decision to offer for sale a wide variety of products may contribute favorably to a marketing department goal of maximizing sales revenue, but may have an unfavorable effect on a production department goal of minimizing production cost per unit, or on the finance department goal of minimizing the expense of obtaining and holding resources. It is an important function of a manager to integrate the activities under his span of control in order to resolve such conflicts in an optimum manner. Of course, a manager requires information in order to accomplish this. Since the organizational goal is profit maximization, and since the accounting information system provides measures of profit, the information necessary to resolve problems of suboptimization and goal conflict is often accounting information.

THE CORRESPONDENCE OF ACCOUNTING INFORMATION SYSTEMS AND ORGANIZATION STRUCTURES

In Chapter 1 the two basic functions of management in an organization were defined as planning and control. These two functions are performed through the medium of organizational structure. An overall plan for the business organization is subdivided into more specific plans for lower level organizational units. At each level, plans are subdivided into lower level plans with the objective of providing effective coordination among all organizational units at that level. Control in the sense of implementing plans is carried out within organizational units at the lowest levels, under the supervision of managers acting in accordance with plans. Middle and higher level managers reinforce this control by monitoring the performance of the organizational units whose managers report to them relative to the plan. Where actual performance does not compare favorably to the plan, control action is initiated by the managers responsible for the organizational unit in which the deviation took place. Organizational structure is therefore clearly essential to the effective performance of the management functions of planning and control in large organizations.

In turn, the performance of the planning and control functions requires information. Within a business organization much of this information is provided by the accounting information system. Examples which are discussed in this section include budgets, performance reports, and sales analyses. The discussion emphasizes that each of these products of the accounting information system is structured in a manner which corresponds exactly to the structure of the organization. And since much of the output of accounting information systems must correspond to organizational structure, many input and processing activities also must reflect this correspondence.

Accounting Information Systems for Planning

A *budget* may be defined as a formal statement in financial terms of the plans of an organization. The budget for a business organization is prepared by its accounting information system in conjunction with production, sales, and other operating departments, and in accordance with policies prescribed by management. The structure of the budget must correspond to the structure of the organization. Therefore, the overall budget of an entity is made up of a hierarchy of smaller budgets, which corresponds to the hierarchy of the organizational structure. Each organizational unit has a budget, which represents its plan for achieving its assigned subgoal, expressed in financial terms.

The process of preparing the annual budget for a business organization begins with the sales forecast. Detailed predictions of the quantities of each individual product to be sold during the budget period are prepared at the lowest level of the marketing organization. These predictions are aggregated, adjusted, and approved by each field manager, who then submits them to his immediate superior for approval. This process is continued until a complete

sales budget for the organization is developed. This budget not only summarizes total predicted sales for each of the products in the organization as a whole, but also provides a breakdown of these totals for every organizational unit within the sales organization.

The sales budget must then be disaggregated to provide an estimate of the level of activity for every organizational unit in the firm during the budgeted period. For example, if the sales budget estimates total sales of 45,000 units of product X, this total may be disaggregated by assigning Plant A to produce 25,000 units and Plant B to produce 20,000 units. These production goals in turn provide a basis for estimating the level of activity required within individual departments of the two plants. From this a forecast of the expenditures required for each department is prepared. These expenditures may be categorized according to the important types of activities engaged in by the department. The result is the departmental budget – an explicit statement in financial terms of the subgoals for which the department is responsible.

Accounting Information Systems for Control

A budget represents a standard of performance established by management for the achievement of the goals of the organization. As such, a budget provides a basis for management control. A significant feature of the control function is the comparison of actual performance to planned performance. Measurement and reporting of such information is provided by the accounting information system in the form of performance reports.

The structure of the performance reporting system in a business organization must correspond to the organization structure in the same manner as does the budgeting system. In fact the performance report is typically an extension of the budget. For a given organizational unit, say, for a production department whose manager is a foreman, the performance report shows budgeted costs and costs actually incurred. Also shown is the difference between these costs which is a measure of the success or failure of the foreman in achieving the assigned subgoal of his department. The performance report is thus a powerful tool in evaluating the performance of the foreman, as well as in directing his attention to matters which most deserve it.

The effective use of budgets for these purposes requires that the system incorporate two additional concepts, flexible budgeting and controllable costs. *Flexible budgeting* involves adjusting the budgeted elements of the performance report for differences between the forecasted level of activity and the actual level of activity. This places the budgeted costs and actual costs on a comparable basis, which is necessary for the performance report to be equitable. *Controllable costs* are those over which a manager, through the exercise of his delegated authority, has some influence. To the foreman of a production department who has no influence over the purchase of assets, depreciation on his department's machinery is not controllable. To the same foreman, however, materials usage and labor usage represent controllable costs. A performance

report should focus on controllable costs in its comparison of budgeted and actual costs.

Moving to higher levels of the organizational structure, the total costs of lower level departments become single-line items on the budgets and performance reports of higher level managers. For example, refer to the organization chart of Fig. 2.2. The total cost of each individual production department becomes a single-cost figure on the budget and performance report of the General Foreman. The total cost under the control of the General Foreman becomes a single-line item in the budget and performance report of the Plant Manager. This correspondence of level of aggregation of budgets and performance reports to level of supervision exists throughout the organization.

The process of budgetary control illustrates well the principal of management by exception. Where the performance report shows actual costs of less than, or only slightly greater than, budgeted figures, a manager can assume that the item is under control. On the other hand, where actual costs are significantly higher than budgeted costs, management is made aware of an item of cost that may be out of control. The exception triggers a study of the situation and, where needed, action to correct the problem.

A related example of control information generated by an accounting information system is provided by sales analysis reports. For example, consider a Regional Sales Manager in the organization chart of Fig. 2.2. Assume that his performance is evaluated on the basis of a comparison of actual unit and dollar sales with forecasts of same. Performance reports which emphasize solely the minimization of costs are not greatly important to such an executive, or to his superiors. A Regional Sales Manager is likely to be more concerned about such things as who are his most effective salesmen, which areas within his region are the best and which are the worst for sales, and which products are the best sellers within his region.

As a by-product of the processing of sales transaction data, the accounting information system can make all of this information available to the Regional Sales Manager. The only requirement is that each sale document which is supplied to the system contain an indication of the salesman, the district, and the product. These may be in a numerical code to facilitate processing. Every two weeks or once a month, the data accumulated on all sales can be analyzed to produce reports on budgeted and actual dollar and unit sales per salesman, per product, and per district. These reports can then be communicated to the Regional Sales Manager to assist him in decision making to satisfy his responsibilities.

In general terms, the position and responsibilities of managers in a business organization provide useful insight into their needs for information. Knowledge of the organizational structure and the division of authority and responsibility within an entity is thus essential to a designer of accounting information systems. Once the nature of the desired output of the system is known, the system designer can concentrate upon structuring the system to most effectively produce that output.

Accounting Information Systems for Data Processing

If the structure of outputs from the accounting information system must correspond to the organizational structure within a business entity, it seems logical that the structure of data collection and processing activities should reflect a similar correspondence. This can be demonstrated by many examples. Within the input stage of the data processing cycle, the design and performance of the recording function must clearly be consistent with the nature of the information to be generated from the data recorded. To cite the example of the previous section, if the information system is to produce sales analyses by product for each salesman and region, then the document upon which sale transactions are recorded must indicate the product sold, the salesman, and the region. Source documents must therefore be designed to capture the significant organizational implications of each transaction they record.

The aspect of the accounting information system which embodies organizational structure most distinctly is the system of classification of input data, or chart of accounts. The chart of accounts contains a series of codes which are used as a basis of classifying accounting transaction data. Two of the primary elements of each transaction which a code must indicate are (1) the journal account into which each transaction amount should be entered, such as accounts payable or direct labor cost, and (2) the organizational unit responsible for the transaction. For example, a small manufacturing company might utilize a five-digit code in which the first two digits indicate the organizational unit and the last three indicate the journal account. While the journal account codes need not be of concern here, an illustration of departmental codes is provided in Fig. 2.3. The department names shown correspond to those in the organization chart of Fig. 2.2.

Applying this set of codes to some specific sample transactions, consider the following: an expenditure for direct labor within Factory Department B; a requisition of raw materials from Stores by Factory Department A; a sale on account within Sales Region D; the purchase of office fixtures for use in the Controller's office; and a consultant's fee incurred by the Information Systems Department.

The direct labor expenditure would be debited to an account coded 22nnn, where "22" refers to Factory Department B, and "nnn" refers to the journal account, Work-in-Process–Direct Labor. The account credited would be 00nnn, where "nnn" refers to the Payroll account. The "00" is used as the department code to indicate that the Payroll account is a general account not applicable to any particular organizational unit.

The materials requisition would result in a debit to an account coded 21nnn, where "21" indicates that Factory Department A accepted responsibility for the materials, and "nnn" is the journal account code for Work-in-Process – Direct Materials. The credit for this transaction would be made to an account coded 17nnn, where the "17" indicates that the Stores Department relinquished its responsibility for the materials, and "nnn" indicates the journal account code for Raw Materials Inventory.

00	General Accounts
01	President
10-29	Production Department
10	Vice President-Production
11	Purchasing
12	Production Planning
13	Engineering
14	Plant Manager
15	Shipping
16	Maintenance
17	Stores
18	Receiving
20	General Foreman
21	Factory Department A
22	Factory Department B
23	Facotry Department C
24	Factory Department D
25	Factory Department E
30-49	Marketing Department
30	Vice President-Marketing
31	Advertising and Promotion
32	Product Planning
33	Customer Service
34	Marketing Research
40	Sales Manager
41	Sales Region A
42	Sales Region B
43	Sales Region C
44	Sales Region D
45	Sales Region E
50-59	Finance Department
50	Treasurer
51	Investor Relations
52	Credit and Collections
53	Insurance
54	Cashier
60-79	Accounting Department
60	Controller
61	Budgeting
62	Tax Planning
63	Internal Audit
70	Accounting Manager
71	Accounts Receivable
72	Billing
73	Accounts Payable
74	General Ledger
75	Payroll
76	Cost Accounting
77	Inventory
78	Timekeeping
80-89	Personnel Department
80	Vice President-Personnel
81	Employment
82	Education and Training
83	Welfare and Safety
84	Personnel Administration
90-99	Information Systems
90	Vice President-Information Systems
91	Systems Analysis
92	Programming
93	Processing Supervisor
94	Computer Operations
95	Data Preparation

Fig. 2.3 Sample departmental codes for chart of accounts.

The sale transaction would be debited to account 00nnn – General-Accounts Receivable, and credited to account 44nnn – Sales Region D-Sales Revenue. Note that only the region is reflected by the account number. An indication of the salesman, the product, and the customer would have to be obtained from codes other than those in the chart of accounts.

The purchase of office fixtures for the Controller's office would be debited to account 60nnn – Controller's Office-Furniture and Fixtures. The credit would be to account 00nnn – General-Accounts Payable.

The account code used to charge the consultant's fee would depend upon which manager within the Information Systems Department had received the consulting services. For example, if the services had veen performed for the Processing Supervisor, the appropriate department code would be "93." If the services had been performed for the Vice President-Information Systems, "90" would be the appropriate department code. The journal account portion of the code would be the same in either case, for the account entitled General & Administrative Expense-Consultant's Fees. The credit portion of the entry would be made to an account coded 00nnn – General-Accounts Payable.

In general, all costs and expenses incurred by the organization should be charged to an account coded to indicate the department for which the cost or expense is controllable. All sales should be coded to reflect the regional department which generated the sale. Asset accounts such as Inventories or Fixed Assets may be coded to indicate the department which has custodial responsibility for the asset. All other accounts are mostly general or control accounts, such as Cash, Accounts Payable, or Payroll, and need not contain any specific departmental code.

Once accounting transaction data are recorded and classified, several other data processing activities performed upon them reflect the need for information output which corresponds to the organizational structure. Many of these activities rely upon the codes provided by the systems of classification used at the data input stage. For example, cost and expense data may be sorted by department code and then summarized for each department to generate reports of controllable costs for all departments. The coding system is used to perform the function of filtration in preparing these reports so that performance evaluations will be based primarily upon controllable costs. The function of comparing is performed with respect to budgeted and actual costs within each department, and comparisons of the direction and magnitude of variances between individual departments may also be relevant. The indexing of these data as a prelude to their storage will also use coding systems corresponding to the organizational structure in order to facilitate retrieval of information for comparison and analysis of past trends within and among departments.

In summary, organizational structure affects the design of the accounting information system in several respects. The effect is evident in all stages of the processing of accounting data, from input and processing to output. A designer

of accounting information systems must understand the organizational structure of the entity which he serves in order to properly incorporate the structure into his designs.

ORGANIZATION OF THE ACCOUNTING FUNCTION

Study of the general concepts of organization is important to the study of accounting information systems because of the close correspondence of such systems with organizational structures. However, the effectiveness of the organizational structure itself is not one of the primary concerns of the systems designer, though he may at times make some recommendations in this regard as a corollary of his systems design work. Generally he will accept the structure of the organization as given, and attempt to fit the information system to the existing structure.

The way in which the accounting and information processing functions are organized may have a significant influence upon the effectiveness of an accounting information system. Therefore, recommendations concerning the organization of these particular functions are a legitimate concern of the accounting systems designer. For this reason, the organization of the accounting and information processing functions will now be examined in greater depth.

Internal Organization of the Accounting Department

Figure 2.2 provides one example of how the accounting function in a typical manufacturing company might be organized. The portion of Fig. 2.2 concerned exclusively with the accounting function is reproduced in Fig. 2.4. It should be understood that the illustration does not represent a prescription for all organizations, but merely serves as an example reflecting patterns of organization that are somewhat common in practice.

The chief accounting executive is commonly referred to as the *Controller*. The Controller is a top level executive in most business organizations, ranking equally with or one level below the other Executive Vice Presidents. As such he is a participant in top level decision making affecting the entire organization.

Shown reporting to the Controller are the staff functions of budgeting, tax planning, and internal audit. The budgeting function involves the preparation of operating budgets, capital expenditure budgets, and related forecasts and analyses to assist management in planning and controlling the operations of the organization. The tax planning function involves the administration of tax reporting activities and planning of transactions having significant tax effects in order to minimize the total long-run tax liability of the organization. The internal audit function is described more fully in the paragraph below. In large business organizations there are likely to be several additional staff departments reporting to the Controller, whereas in small or medium-sized companies the Controller by himself, or together with a single assistant, may per-

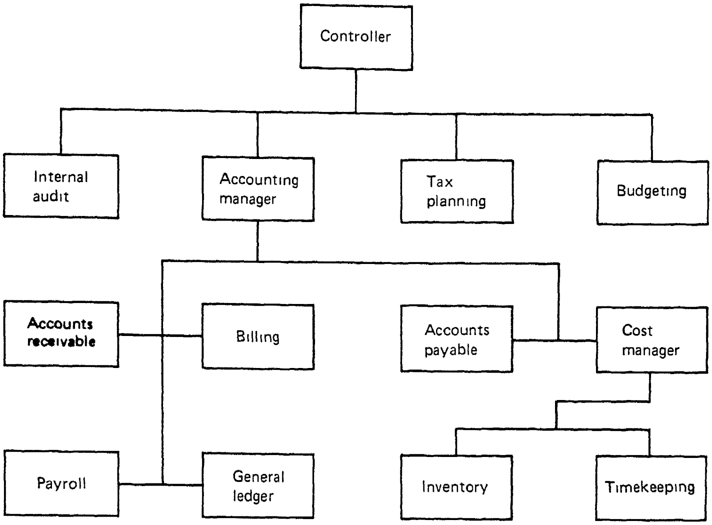

Fig. 2.4 Internal organization of a typical accounting department.

form all of these functions. Also shown reporting to the Controller is an Accounting Manager, whose responsibility is to supervise the routine operating functions of the accounting department.

An active internal audit department exercises an important role in a well-managed business. The responsibilities of the internal audit function typically include: (1) independent appraisal of the performance of various levels of management with regard to efficiency and adherence to company policies; (2) continuous review and recommendation of improvements in the system of internal checks and protective measures in the organization; (3) periodic assessment of the reliability of financial records and the effectiveness of processing methods; (4) the execution of certain miscellaneous control functions which must be performed independently of other operating units. Examples of the latter function include the preparation of bank reconciliations and the control of cash register tapes. Because of the necessity for independence and objectivity in this function, many companies require that the internal audit executive report to the President or Board of Directors instead of, or in addition to, the Controller.

The distribution of general accounting functions shown in Fig. 2.4, in accordance with major transaction account categories, is fairly typical. In many manufacturing organizations, the cost accounting function is fairly large, and may be responsible directly to the Controller, rather than to the Accounting Manager. The billing function is distinguished from accounts receivable in that billing is responsible for sending out invoices at the time of sales, whereas accounts receivable is responsible for the records of customer accounts and for sending out periodic statements of account.

Two functions closely related to the accounting function are not shown in Fig. 2.4, but are instead shown reporting to the Treasurer in Fig. 2.2 These are the functions of cashier and of credit and collections. The cashier is responsible for maintaining a record of cash receipts, endorsing and depositing checks, and reviewing and/or signing checks disbursing company funds. The credit and collections function involves the establishment of credit policies, the granting of credit to customers, and in some cases the administration of mail room procedures relative to the receipt of customer payments through the mail. In some companies one or the other or both of these functions may be performed within the accounting department itself.

An important consideration in the organization of these accounting and related functions is the maintenance of organizational independence. In general, organizational independence can be effectively maintained by means of separating recording functions from custodial functions. Thus it is essential, for example, that responsibility for mail collection and initial recording of cash receipts be separate from the responsibility for endorsing and depositing cash receipts, and that the latter function be separate from the maintenance of accounts receivable records. Likewise, the cashier's function of disbursement of company funds must be separate from the function of authorizing disbursements, commonly performed by the accounts payable department. The payroll function, which involves the preparation of employee paychecks, must be separate from the timekeeping function. Furthermore, with respect to inventories, recording and custodial functions must be separated from operating functions (the production departments). Responsibility for custody of inventories is commonly fixed in a stores-keeping function within the factory, whereas recording of inventories is usually one of the responsibilities of the cost accounting function.

In the sample organization chart, the clerical functions within the accounting department have been detailed to a degree which is somewhat out of proportion with the level of detail in other areas of the chart. In all but very large single-plant operations, the clerical functions shown reporting to the accounting manager would likely be performed by one or two persons each, rather than by completely separate departments. Furthermore, in organizations using a computer system, some of these clerical functions, particularly billing, payroll, and inventory, might well be completely replaced by the computer. It should therefore be understood that the primary purpose of the sample chart is to illustrate common patterns of distribution of functions within accounting departments and the application of the principle of organizational independence. It bears repeating that the chart is *not* intended to be a model of how manufacturing companies *should* be organized, for each company must adopt a structure which is best suited to its own particular needs and characteristics.

Relationship of the Accounting Function to the Computer Activity

One factor which has in recent years had a far reaching effect upon patterns of company organization is the increased information capabilities provided by the computer. The installation of a computer system in a company creates a completely new department, with new responsibilities, a new set of employees, and new problems. Since computers began to be applied on a major scale in business in the 1950's, a wide variety of patterns of locating the computer activity in the organization have evolved. According to one survey,[2] the most common arrangement is for the top computer executive to report to the controller or to the vice president of finance, which was the case in 58% of the companies surveyed. Among other possibilities, by far the most common is for the top computer executive to be a vice president having equal status with the controller, treasurer, and other vice presidents. This arrangement is illustrated in Fig. 2.2, with the top computer executive having the title "Vice President of Information Systems."

A somewhat less common pattern, which exists where one of the major departments in a company has a special need for a computer which is unique to the company or industry, is for the computer activity to be located within a particular department, such as manufacturing or marketing. Still another possibility, which could become quite popular, is for the accounting, finance, and information systems functions to be combined under the authority of a Vice President for Administration, as illustrated in Fig. 2.5.

One factor which helps to explain the frequency with which the computer activity is located under the controller or financial executive is that early computer applications were primarily to accounting operations, such as payroll, billing, or inventory. These applications have been among the first to be automated because of their routine nature, which makes them relatively simple to program. Those who support the location of the computer function within the accounting department argue that it is only logical for the computer to be located within the department responsible for the majority of the data processing workload. They further argue that the major reorganization necessary to create a computer department separate from the accounting department is quite costly in terms of disruption of familiar organizational relationships. They cite the traditional role of the accounting department in supplying information to managers in all other functional areas, and argue that the separation of responsibility for information preparation between two major departments makes very little sense.

Those who oppose the location of the computer activity within the accounting department argue that the nature of computer applications has evolved to the extent that most or all departments in an organization are likely

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[2]Neal J. Dean, "The Computer Comes of Age," *Harvard Business Review*, January-February 1968, pp. 83-91.

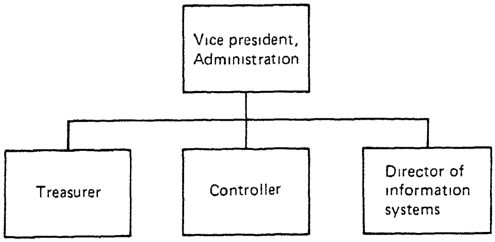

Fig. 2.5 Organization of the accounting, finance, and information systems functions under a Vice President of Administration.

to be interested in applying the computer to their own individual needs or problems. They feel that accountants naturally possess certain biases which limit their capacity to manage the computer activity in a manner which encourages the profitable application of computers throughout the organization. For example, systems personnel responsible to a controller may have a tendency to favor the development of financially oriented applications. Similarly, computer operations personnel may feel obligated to give top priority in processing schedules to accounting work. They further argue that the narrow perspective of accountants leads to premature rejection of applications whose benefits cannot be tangibly measured in dollars, and that systems designs prepared by accountants tend to emphasize processing efficiency rather than analysis of the information needs of users.

Those who favor the location of the computer activity in a separate department reporting to a top level executive argue that this separation is necessary to free the computer facility from the biases of accounting management. They argue that specialists in accounting or any other functional area are generally not sufficiently well qualified to manage the computer activity. They feel that a top level computer executive can make important contributions to top management planning and control for the organization. They argue that this arrangement is the only one in which the top computer executive obtains the organizational status necessary for him to bring about integration of functions leading toward a total information system.

Creation of the position of Vice President for Administration is advocated not only as a compromise in the computer location controversy but also as a more effective means of controlling administrative staff activities generally. It reduces the potential for lack of objectivity on the part of the executive responsible for the computer system, since the Vice President for Administration is presumably a neutral officer. It also appeals to those who do not believe that a top computer executive is generally qualified to serve in a top management position with vice presidential status.

Several trends of recent years may have reduced the significance of the computer location controversy. One is a trend toward treatment of a computer facility as a profit center which charges other departments for its systems

development and data processing services. This shifts the responsibility for deciding the worth of new computer applications from the systems group to the users. As a result, the basis for conflict over decisions regarding the use of computer resources is eliminated. As a profit center, the computer facility is willing to provide any service which a user is willing to pay for at market rates.

A second trend is technological in origin – a movement toward small computers, computer terminals from which larger systems are accessible, simple programming languages, and "packaged" application programs. This makes computer resources more readily available to personnel throughout an organization, rather than completely concentrated under the control of a single department. This also tends to lead to a reduction of conflict over the use of systems development and data processing resources.

A third trend is philosophical, and consists of a growing disillusionment with the concept of a totally integrated management information system. Integration is being interpreted as a relative, rather than absolute, concept. Implementation of the concept is seen as practical only up to a point which falls short of a total system. For example, many manufacturing companies have found it worthwhile to integrate information systems for purchasing, inventory, production, and engineering functions. However, there is little or no common basis for integration of the information systems of, for example, the engineering, personnel, and sales functions. This trend in the thinking of systems theorists and practitioners[3] should tend to reduce pressures favoring top executive status for the manager of the information systems department.

In summary, the issue of organizational location of the computer facility is an unresolved one, both generally and in many specific organizations. Recent trends seem likely to diminish the importance of the issue. One certainty is that each organization is unique, and therefore must search for a means of organization which is best suited to its own individual circumstances.

Regardless of where the computer activity is organizationally located in a company, it has the effect of taking over some of the functions which were previously performed within the accounting department. In terms of a particular application, the steps of implementation and operation are executed primarily by computer staff specialists, whereas the analysis and design steps are a mutual function of the computer staff specialist and the accountant, with the accountant in the role of user. This redistribution of functions has the effect of reducing the amount of routine clerical work done in the accounting department, and in increasing the opportunities for the accounting department to apply itself to more creative activities requiring knowledge, judgment and higher levels of skill.

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[3]For further elaboration of this point of view, see John Dearden, "MIS is a Mirage," *Harvard Business Review*, January-February, 1972, pp. 90-99 and Peter P. Schoderbek and Steven E. Schoderbek, "Integrated Information Systems – Shadow or Substance," *Management Advisor*, November-December, 1971, pp. 27-32.

On the surface it might seem that the separation of accounting and information processing functions would reduce or eliminate the accountant's role as a supplier of information to decision makers in all areas of the organization. Two factors can be expected to prevent this isolation of the accounting function. First, as long as concern with reducing costs and maximizing profits remains significant in business organizations, all organizational units will require financial information to aid in setting objectives and executing plans to meet those objectives. The accountant's role as a specialist in designing systems to supply these information needs will still be necessary, regardless of how the information is processed.

Second, much of the information which is useful to nonaccountants is generated as a by-product of the processing of transactions, which is a basic accounting function. For example, much of the information useful to a marketing manager is generated from the processing of sales transactions. This indicates that a close relationship between accounting and other departments will continue to be necessary in order that systems can be designed which will efficiently produce the maximum quantity of useful information.

The perspective from which this book is written is that of the designer of accounting information systems. In organizations where the accounting and information processing functions are separate, the need for such a role to exist within the accounting department is just as essential as if no separation existed. Such a person must have a specialized knowledge of accounting, together with a familiarity with both the information needs of all other functional areas in the organization, and with the capabilities and limitations of the computer as a tool for supplying these needs. The aim of this book is to contribute to the development of such a perspective.

ORGANIZATION OF THE INFORMATION SYSTEMS FUNCTION

Whereas the question of location of the information systems function within a business organization is discussed in the preceding section, this section discusses the internal organization of the function. An example of the internal organization of the systems function for a medium- to large-sized company is provided in Fig. 2.2. For purposes of the discussion in this section, an illustration of the internal organization of a somewhat larger systems functions is shown in Fig. 2.6. This illustration is not intended to provide a prescription for systems organization in all companies, but is merely an example which reflects common patterns of organization in practice and therefore offers a basis for discussion.

As previously mentioned, the top manager of the information systems function may or may not be a Vice President having equal status with other top level executives in the organization. In firms where he is a member of top management, he is a participant in setting objectives for the organization, in long-range planning to meet objectives, in establishing broad policies for

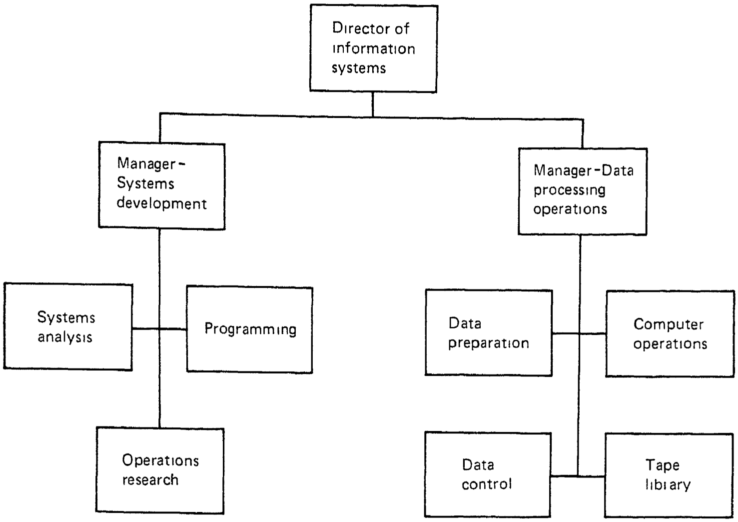

Fig. 2.6 Internal organization of the information systems function.

the organization, and in top management decision making. One of his primary contributions to these activities is his ability to articulate the extent to which the information system can contribute to the achievement of plans and objectives and the execution of policies and decisions. He is also in a position to encourage the profitable use of the information system in all other functional areas of the organization.

Regardless of whether the top computer executive has the status of Vice President, he must perform the role of manager of the systems activity. In this role he is responsible for the development of profitable new applications and the efficient processing of existing applications. He is accountable for the costs associated with the equipment and personnel required for the system. He is responsible for maintaining a modern up-to-date facility which takes maximum advantage of new technological developments. Such responsibilities require a good combination of administrative skills and technical competence.

The Manager of Systems Development is responsible for managing the work of developing new systems designs and improvements in existing systems. He must establish and enforce standards for systems design, programming, and system documentation. He is responsible for planning and controlling the implementation of new systems applications. He is accountable for the costs and progress of systems development efforts. Responsible to him are specialists in systems analysis, operations research, and programming.

The systems analysis function involves the design of computer applications to satisfy user needs in an organization. The position of systems analyst requires both experience in systems design and familiarity with the operations of the organization, for this person must serve to bridge the gap between the

user and the technology of the computer system. The programming function involves converting the designs of the analyst into a set of computer instructions. Programming is generally regarded as a lower level position than systems analysis, since the position does not require the same degree of familiarity with the organization's operations. The operations research function is concerned with the development and application of mathematical modeling approaches to management problems. This function is not located within the systems department in all companies, but the fact that its practitioners make frequent use of computers makes the location a convenient one.

In some large organizations the systems development activity is not organized by specializations, but by projects. Each systems application project in the development stage has a project manager who supervises a group of systems analysts, programmers, and possibly operations researchers working together from design to implementation. All project managers report to the manager of systems development. Though not appropriate for all organizations, particularly smaller ones, this approach has proven to be an effective means of managing systems development activities in many organizations.

The Manager of Data Processing Operations is responsible to the top computer executive for the day-to-day performance of data processing operations. Once new systems designs have been fully implemented, their successful execution becomes the responsibility of this department. As shown, a common pattern of division of responsibilities within this department involves separation among the functions of: (1) data preparation, (2) computer operations, (3) tape custodianship, and (4) data control. The data preparation function involves the preparation and verification of source data for computer processing. In many firms the major data preparation activity is keypunching, though it also commonly includes the operation of data processing hardware peripheral to the main computer. The computer operations function includes operating the computer and its input and output devices in accordance with the processing schedule. The tape custodianship function is responsible for maintaining a separate storage area, or "tape library," for files and programs which are stored on magnetic tape. The data control function maintains a record of all work in process and monitors the flow of work within and through the processing department. As part of its function, the data control group is responsible for checking input and output for correctness, and for assuring that established control procedures are adhered to during processing operations.

The accounting department is interested in the internal organization of the information systems department in several respects. Because of his responsibility for internal control within the organization, the internal auditor is concerned that appropriate controls over data processing operations be established and that organizational independence be maintained among the information systems staff. If a control group exists in the data processing section, the internal auditor will likely be responsible for establishing its

procedures and reviewing their application. The main factor in achieving organizational independence in a data processing installation is the effective separation of systems development and processing functions. Because of their familiarity with existing applications, systems analysts and programmers could possibly manipulate programs for fraudulent purposes. However, if they are not authorized to have access to computer equipment, or to tapes of records and programs, their chances of accomplishing such manipulation are remote. Similarly computer operators are restrained from such manipulation by limits over their access to program documentation and tapes of files and programs, and by close supervision of their work.

The accounting department in its role as the primary user of the information processing facilities is likely to have a close working relationship with the information systems department. Systems analysts and accounting staff personnel will frequently be working together in designing new applications or revising existing ones. Accounting personnel connected with functions which have been computerized will have regular contact with the processing section. Another aspect of this relationship is the fact that the information systems department is a responsibility center for which budgets and performance reports must be prepared by the accounting department.

IMPACT OF THE COMPUTER ON PATTERNS OF ORGANIZATION

The advent of the computer and related information technology has and continues to have a profound impact upon organizational patterns within the business world. One example concerning the issue of organizational location of the computer activity has already been discussed. At this point several other related issues of computer impact upon organizations are identified and briefly discussed.

Centralization or Decentralization of Management

Prior to the advent of computers a trend toward decentralization of management functions had existed in business. Large multi-division companies could not effectively make decisions for, and exercise control over, far-flung operating divisions. This was true because accounting, the primary information supplying function, did not have available the technology to provide company headquarters with adequate information on a timely basis which was necessary to make decisions at the operating level.

The increased information processing capability provided by the computer could have the effect of eliminating this trend toward decentralization. The computer enables company headquarters to receive more timely and reliable information in greater quantities from the operating divisions. This would seem to provide top management with the capability to centralize decision making for operating divisions. Whether a trend back toward centralization will take place is not yet evident. Some would argue that top managements will tend to use this capability not to make operating decisions, but to provide

better information to, and hence improve the decision making of, the operating managers over whom closer control can then be exercised.[4]

Centralization or Decentralization of Information Systems

An issue separate from the problem of centralization or decentralization of management itself is the appropriate degree of centralization of the information systems function in a large organization. A highly centralized information systems function offers several advantages, including: the economies of scale accruing to larger computer systems; the ability to achieve integration of systems more effectively; and the availability of better opportunities in a larger installation, which is more attractive to highly qualified personnel. However, decentralization of information systems activities also offers significant advantages, including: closer proximity to system users, which enables better understanding of user needs; greater motivation among divisional managers and personnel to seek profitable computer applications; and a diffusion of the risk of system failure.

Effect on Management Tasks

Another hotly debated issue has been the effect of information technology upon the functions performed by management, especially middle management. Some have suggested that computers would take over the routine decision-making functions of middle management, and result in a greater degree of centralization of creative activities within the higher management levels.[5] As middle management was eliminated, the shape of the organization structure would shift from the form of a triangle toward the form of an hourglass. Others suggest that computers will not eliminate middle management, but will remove the routine tasks from this group and give them more time to concentrate upon the creative aspects of their jobs. No clear pattern has yet emerged with respect to this question.[6]

Examining this question very carefully, Whisler suggests that management functions can be delineated into four basic categories: (1) problem solving, (2) communication, (3) goal setting, and (4) pattern perception, or the recognition of problems and opportunities. He argues that computers possess advantages over man with respect to the functions of problem solving and communication of expected results. However, he does not foresee an ability for computers to replace managers with respect to goal setting, pattern perception, or the motivational aspects of communication.[7]

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[4]See for example John F. Burlingame, "Information Technology and Decentralization," *Harvard Business Review,* November-December, 1961, pp. 121-26.

[5]The classic statement of this position is found in Harold J. Leavitt and Thomas L. Whisler, "Management in the 1980's," *Harvard Business Review,* November-December, 1968, pp. 41-48.

[6]For further discussion of this subject, see Hak Chong Lee, "The Organizational Impact of Computers," *Management Services,* May-June, 1967, pp. 39-43.

[7]Thomas L. Whisler, *Information Technology and Organizational Change* (Belmont, California: Wadsworth Publishing Company, Inc., 1970), pp. 24-26 and 81-82.

Effect on Routine Tasks

Another major issue has evolved from the fear, stimulated to a great extent by organized labor, that automation based upon computers will eliminate large numbers of clerical and production jobs. This may well occur, but it is doubtful that it will generate mass unemployment, as the unions fear. The computer holds the potential for eliminating a great deal of the drudgery that men have always faced in industrial society. As this occurs, many more creative jobs requiring knowledge, judgment, and higher levels of skill are opening up. Hopefully the transitional difficulties in this process of change will be minimal.

In summary the long-range effects of computers upon traditional organizational structures and job responsibilities is not entirely clear. The major point of agreement is that the impact will be profound. Much speculation has been offered by experts on this subject, and the Lee article cited above provides a good synthesis of some of this literature. The process of change is made less orderly by the seemingly continuous advancements being made in information technology. The future promises to be hectic but interesting.

REVIEW QUESTIONS

1. Define the following terms:

   organizational independence
   organization
   hierarchical
   levels of supervision
   span of control
   suboptimization
   goal conflict
   budget
   flexible budgeting
   controllable costs
   controller

2. Why is an understanding of concepts and practices of organization important to the study of accounting information systems?
3. Can responsibility be delegated? What is the relationship of responsibility to authority delegation?
4. Explain the concepts of centralization and decentralization of authority.
5. Identify and briefly explain four prominent problems of modern organizations and their implications for information systems.
6. What is the commonly accepted goal of business organizations? In what way does organizational structure contribute to the achievement of that goal?
7. What is a subgoal? What relationship does the performance report have to subgoals of business entities?
8. Describe an example of goal conflict in a business organization.
9. Explain how organizational structure contributes to the effective performance of the management functions of planning and control.

10. Describe the steps in the process of preparing the annual operating budget in a business organization.
11. Explain the relationship of a performance report to a budget.
12. How does management by exception enter into the process of budgetary control?
13. What relationship must exist between the organizational structure and the chart of accounts? Describe several activities within the data processing cycle which are affected by this relationship.
14. What is the responsibility of a designer of accounting information systems with respect to the organizational structure of the businesses he investigates?
15. What are some examples of staff functions reporting to the controller in a typical business organization?
16. What are the responsibilities of the internal audit function in business? What are the issues in the question of to whom the internal audit executive should report?
17. What distinction is there between the billing function and the accounts receivable function in a business?
18. What two general functions must be separated to achieve organizational independence with respect to cash handling functions? Provide several examples.
19. What three general functions must be separated to achieve organizational independence with respect to inventories?
20. What are four existing patterns of location of the computer operation within business organizations?
21. What business data processing tasks were among the first to be automated and why?
22. Describe several arguments both favoring and opposing the location of the computer activity within the accounting department in organizations.
23. What arguments are advanced by those who favor location of the computer activity in a separate department whose manager is a top level executive in an organization?
24. What arguments are advanced by those who favor the creation of a position of Vice President for Administration to whom the Controller, Treasurer, and Director of Information Systems would report?
25. Explain three trends of recent years in the systems field which have tended to reduce the significance of the computer location controversy in organizations.
26. What category of tasks has the computer activity taken over from the traditional accounting function? What category of tasks does the accounting function still perform?

27. In what respects is the accountant's role as a supplier of information for decision making unchanged by the establishment of a separate information systems department in a business?
28. Describe the way in which the information systems function might be organized in a typical large business organization.
29. Describe the nature of the roles played by a top computer executive who is also a member of the top management group in a business organization.
30. Describe the functions performed by a manager of systems development, a systems analyst, a programmer, and a project manager in a typical information systems department.
31. Describe the functions performed by an input preparation department, a computer operation group, a tape library, and a control group within the data processing section of a typical information systems department.
32. In what respects is the accounting function in business interested in the internal organization of the information systems function?
33. Identify and briefly discuss four issues of computer impact upon organizational patterns.

DISCUSSION QUESTIONS

34. What contribution can the accounting information system make to the resolution of goal conflict within a business organization? (It might be useful to refer to the product line example presented in the chapter.)
35. It is stated in this chapter that "Business organizations generally interpret their primary goal to be the maximization of long-run profits." Is this goal in conflict with social goals such as a clean environment and a lasting world peace? Can the accounting profession contribute to the resolution of such conflicts of business and social goals?
36. Do you believe that it is possible to generalize with respect to the proper organizational location of the computer activity in business? Why or why not? Discuss.
37. Discuss the future impact of computers and automation upon the nature of job responsibilities and upon unemployment in society.
38. Discuss the similarities and differences between the organization structure of a business and of a university. What do you suppose is the nature of the role played by an accounting information system within a university?

PROBLEMS AND CASES

39. Prepare a simple illustration of an organizational hierarchy. Using a set of descriptive labels, identify one example within your illustration of each of

the following:

a) a manager,
b) an organizational unit,
c) the goal of the organization,
d) a subgoal,
e) delegation of authority,
f) reporting responsibility, and
g) span of control.

40. In the Carlton Manufacturing Company, the foremen of three production departments (Machining, Assembly, Finishing) and one service department (Maintenance) report to the Plant Supervisor. Among the Plant Supervisor's other responsibilities are the making of recommendations concerning salary increments for these foremen and his own staff and the making of recommendations concerning equipment purchases for the departments under his span of control.

The following summary of costs for the Assembly Department for the month of May, 1973, was compiled for use in inventory costing:

Cost	*Budget*	*Actual*
Direct Labor	$3,500	$4,000
Materials Spoilage	200	210
Overtime Premium	500	580
Reassembly	400	390
Supplies and Small Tools	300	310
Foreman's Salary	650	650
Allocation of Depreciation on Building	100	100
Allocation of Depreciation on Equipment	100	120
Allocation of Plant Supervisor's Salary	200	200
Allocation of Salaries of Plant Supervisor's Staff	250	260
Allocation of Maintenance Dept. Costs	1,200	1,290
Total	$7,400	$8,110

Additional Information

- Budgeted costs are based upon budgeted activity of 1,000 units of production. Actual number of units of production was equal to 1,100.
- All other departments also exceeded their budgeted activity level by exactly 10%.
- Maintenance Department Costs are allocated in three equal amounts to the three production departments.
- All other allocations are made in four equal amounts to the four departments under the Plant Supervisor.
- Budgeted and Actual Salaries for the four department foremen total $2,500, including $650 for the Maintenance foreman.
- Depreciation is computed on a straight-line basis. Equipment has been purchased during 1973 which was not included in the initial budget for the year.

Required:

a) Categorize each cost in the above list according to whether it is: (1) controllable by Assembly Department foreman; (2) controllable by Plant Supervisor; (3) controllable by neither.
b) Categorize each cost in the above list according to whether it is: (1) fixed, or (2) variable with the level of activity.
c) Prepare a performance report for the month of May for the Assembly Department foreman. Assume that it is company policy for performance reports to include only controllable costs, and to use the principle of flexible budgeting.
d) The total actual cost from the performance reports for the Machining and Finishing Departments, and the total budgeted cost for these departments according to the budgeted (rather than the actual) activity level are as follows:

Department	*Budget*	*Actual*
Machining	$2,500	$2,800
Finishing	2,000	2,100

Applying the same company policies described in part (c), prepare a performance report for the Plant Supervisor.

41. Explain how the principle of organizational independence is being violated in each of the following situations.

a) A payroll employee recorded 40 hours worked for the week for an employee who had quit the previous week. He then prepared a paycheck for this employee, cashed it by forging the signature, and kept the cash.
b) While opening the mail, the cashier set aside two checks payable to the company on account. He later cashed these checks and pocketed the cash.
c) The cashier prepared a fictitious invoice from a company having the name of his brother-in-law, and wrote a check in payment of the invoice, which his brother-in-law later cashed.
d) An employee of the Finishing Department helped himself to several parts from the Storeroom, and recorded the items as being issued to the Assembly Department in the Inventory Ledger.
e) The cashier cashed a check from a customer in payment of an account receivable, pocketed the cash, and concealed the theft by properly posting the receipt to the customer's account in the Accounts Receivable Ledger.

42. The Dobson Manufacturing Company has recently decided to replace its existing punched card data processing system with a computer system. The feasibility study which recommended this step was carried out by the Assistant Controller, who is also the manager of the punched card facility, and by the Assistant Vice President for Production, who is a computer expert.

One of the first steps in planning for acquisition and implementation of the new system is to decide how the change will affect the company's organization structure. The company is currently organized into five major functional areas: Production, Marketing, Personnel, Finance, and Accounting.

Some facts from the feasibility study which bear upon the decision are as follows:

- The budget and staff of the new department will be three times as large as the old punched card department.
- The computer will perform all of the basic accounting functions previously performed by the punched card system.
- The primary justification for the new computer system is the contribution to profit which will be generated as a result of its immediate application to production planning and control.
- Estimated usage of computer time by each of the five functional areas is as follows: Production - 30%; Marketing - 10%; Personnel - 5%; Finance - 5%; Accounting - 50%.
- High potential exists for profitable application of the computer in Marketing, Personnel, and Finance, and total usage of computer time by these three areas should eventually reach 40%.

Required:

Considering all aspects of the situation described, identify and discuss the relative merits of several alternative locations of the computer facility within the organizational structure of the Dobson Manufacturing Company.

43. Stevens Chemical Company is a manufacturer of a wide variety of chemicals, including cleaning fluids, weed and bug sprays, lubricants, and several industrial chemicals used as raw materials by other firms. The company has total sales of about $100 million, and is made up of six operating divisions located in five southern states whose sales range from $6 million to $25 million. The company has always operated under a philosophy of decentralization, wherein each divisional management has authority to set prices, determine its product mix, and establish other policies. Company headquarters has exercised a loose form of budgetary control, generally approving budget requests submitted by divisions, and reviewing divisional performance to the extent necessary to reward division managements for successful performance and to make recommendations for improvement where appropriate. The company has operated profitably under this arrangement for several years, except that in the last two years one division has sustained a loss due to a combination of downward pressures on prices and large increases in selling and administrative costs.

The company's management has recently made a decision to acquire a medium-sized computer system for use at company headquarters. Mr. Thomas Shockley, a former management consultant with the company's

auditors and a specialist in data processing, has been hired as Assistant Controller to be in charge of the computer facility. Mr. Karl Pearson, formerly a Controller at the largest of the company's operating divisions, has been the company's Controller for the last ten years. At present, the new computer is due to be installed within three months, and Mr. Shockley is in the process of supervising staff training, system design, and programming activities.

As a result of his work in preparing for installation of the new computer system, Mr. Shockley has proposed that the company adopt a philosophy of greater centralization of decision-making responsibility. He argues that the major reason for decentralization of such responsibility is that timely and relevant information is not available to top management to enable them to make major decisions for the divisions. He believes that the computer system will make available to corporate headquarters enough relevant information on a timely basis to enable top management to effectively make major decisions for the divisions. Shockley has been authorized to computerize all accounting functions for all the divisions, including billing, payroll, production and cost accounting, accounts receivable, accounts payable, inventory, budgeting, and performance reporting. Performance reports on each division, comparing actual to budgeted results, should be available to corporate headquarters each month, within a week from the end of the month, according to Mr. Shockley. A list of the functions which he feels should be centralized instead of performed at the divisional level includes: (1) establishing pricing policies, (2) deciding on the product lines, (3) purchasing of raw materials, (4) scheduling of production, (5) extension of credit, (6) deciding on capital expenditures, and (7) deciding on salaries and promotions for divisional management personnel.

In discussions of Mr. Shockley's proposal by the company's top executives, Mr. Pearson has argued in opposition to the idea of centralization. He points to the company's long history of profitability under a philosophy of decentralization. He has expressed doubt that the new computer system will be able to provide company headquarters with information that is as reliable, timely, and complete as that available to the division managers. He feels that the freedom provided to division managers has been a significant factor in motivating them to perform successfully.

In response to Mr. Pearson's arguments, Mr. Shockley points out that the company's decision to acquire a computer system places it at a major crossroads. Top management must decide whether the computer will merely become an expensive form of mechanized bookkeeping, or an effective tool contributing to the profitable management of the company. He argues that centralized decision making is necessary because of the increasing lack of coordination of activities of operating divisions, as evidenced by some cases where two different divisions have marketed competing products. He further argues that the computer system will make it more

efficient to centralize the administration function than to continue the policy of decentralization. He cites the case of the division which has incurred operating losses as evidence of the need for more centralized financial control.

Required:

a) Examine the list of functions which Mr. Shockley suggests should be centralized. Which of these functions do you feel could be more effectively performed if centralized? Which could be more effectively performed under decentralization? Explain.
b) Mr. Pearson has expressed doubt that the new computer system will be able to provide company headquarters with information that is as reliable, timely, and complete as that available to the divisional managers. Do you agree? Explain.
c) Mr. Shockley defines the issue at one point as "whether the computer will merely become an expensive form of mechanized bookkeeping, or an effective tool contributing to the profitable management of the company." Do you feel that this is the relevant issue in the case? Explain.
d) Are there any other alternatives to the strict centralization of decision making advocated by Mr. Shockley and the status quo defended by Mr. Pearson? Explain.
e) What action do you feel should be taken by the management of Stevens Chemical Company with respect to the proposal of Mr. Shockley? Which arguments do you feel are the most compelling and why?

Chapter 3

Control and Accounting Information Systems

In an abstract sense, control is the process of exercising a restraining or directive influence over the activities of an object, organism, or system. Assisting management in the control of business organizations is one of the primary functions of accounting information systems.

Accountants often use the term *internal control* as a synonym for control within business organizations. This term has been defined by a Committee of the American Institute of Accountants (now American Institute of Certified Public Accountants, or AICPA) as follows:

> Internal control comprises the plan of organization and all of the coordinate methods and measures adopted within a business to safeguard its assets, check the accuracy and reliability of its accounting data, promote operational efficiency, and encourage adherence to prescribed managerial policies.[1]

The broad nature of this definition is indicated by the references to promoting operational efficiency and encouraging adherence to prescribed managerial policies.

Reference to the "plan of organization" in the definition is an indication of the essential importance to internal control of organizational independence, or the separation of duties among clerical personnel in order to minimize the possibility of embezzlement by any single employee. Reference to "methods and measures" indicates the central role in internal control of the variety of procedures which are carried out in a data processing system to facilitate internal control. In this more specific sense, the term *control* is used to refer to a single procedure within a system of internal control.

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[1]Committee on Auditing Procedure, American Institute of Accountants, *Internal Control* (New York: American Institute of Certified Public Accountants, 1949) p. 6; restated in the Committee's *Auditing Standards and Procedures,* Statement on Auditing Procedure No. 33 (New York: American Institute of Certified Public Accountants, 1963) p. 27. Copyright © 1949 and 1963 by the American Institute of Certified Public Accountants, Inc. and reprinted with permission.

Control systems are of two general types: feedback control systems, and preventive control systems. Feedback control systems operate by measuring some aspect of the process being controlled and adjusting the process when the measure indicates that the process is deviating from plan. *Feedback* is defined as the informational output of a process which returns as input to the process in the sense that it initiates the action necessary for process control. In contrast, preventive control systems operate by attempting to prevent deviations from plan before they occur.

There is a rough equivalence between the distinction of feedback from preventive control systems and the distinction, promulgated by the AICPA in Statement 33 and reaffirmed in a later statement,[2] of accounting and administrative controls. Accounting controls incorporate the internal control functions of safeguarding assets and checking the accuracy and reliability of accounting data, and correspond approximately to preventive controls. Administrative controls encompass the internal control functions of promoting operational efficiency and encouraging adherence to prescribed managerial policies, and are roughly equivalent to feedback controls.

This chapter provides a general description of both feedback and preventive control systems and describes examples of each within the context of accounting information systems.

FEEDBACK CONTROL SYSTEMS

Fundamental Characteristics

A feedback control system contains five fundamental components. In general terms, these are: (1) an operating process which converts an input into an output; (2) a characteristic of the process, which is the subject of control; (3) a measurement system, which assesses the state of the characteristic; (4) a set of standards or criteria against which the measured state of the process is evaluated; and (5) a regulator, whose functions are to compare measures of the process characteristic to the standards, and to take action to adjust the process if the comparison reveals that the process is deviating from plan. The relationships of these components are illustrated graphically in Fig. 3.1.

Incorporating feedback control into a process creates a dynamic, self-regulating system. In such a system, the process is expected to deviate from equilibrium occasionally. However, the ability to restore the process to equilibrium, and to know when such restoration is needed are built into the system itself. Thus it can operate for long periods of time, performing its necessary functions and correcting itself when necessary, without the need for external direction. The theoretical study of feedback control systems is referred to as *cybernetics.*

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[2] Committee on Auditing Procedure, American Institute of Certified Public Accountants, *Reports on Internal Control,* Statement on Auditing Procedure No. 49 (New York: American Institute of Certified Public Accountants, 1971) p. 172.

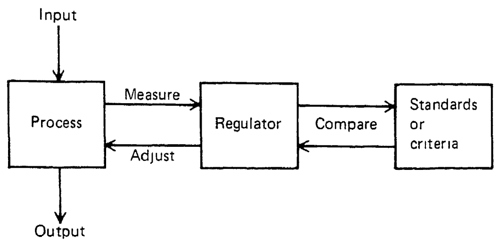

Fig. 3.1 A feedback control system.

A commonly cited example of a feedback control system is the thermostat. This control system operates by measuring the temperature of an object or process, and triggering a heating (cooling) device when the temperature exceeds a specified level of coldness (warmth).

Feedback control systems are common within business organizations. The production of goods or the operation of a department are processes requiring control. Characteristics of such processes which are controlled might be quality of output, cost of operation, or speed of operation. Measurement systems are frequently component parts of the accounting information system. Standards or criteria for evaluating the process are established by management policy. Finally, the regulator is a manager, or person responsible for the satisfactory operation of the process.

Though it is instructive to apply the concept of a feedback control system to various processes within business organizations, it should be noted that business organizations cannot operate as precisely and automatically as say, a thermostat. This is true because of the complexity of business operations and because of the limitations in perception and memory of people generally. However, the concept is useful as a theoretical ideal for control systems in business.

Essentials of a Properly Functioning Feedback Control System

The successful application of feedback control systems in a business organization requires that certain general principles be observed. First it is essential that a control have a benefit value at least as great as the cost of administering it. Deciding whether a given control meets this criteria will usually be a matter of subjective judgment. The cost of a control may not be too difficult to estimate, but its benefit might be expressed only in vague terms, such as "increased efficiency" or "better customer service." Ability to make this judgment with a fair degree of success is one factor which separates good managers from inferior ones. Satisfaction of this principle is essential not only to feedback control systems, but also to preventive control and to all activities of a business.

A second essential principle in a feedback control system is that its measurement component report deviations from standards on a timely basis. This is necessary in order that corrective action can be initiated to restore the pro-

cess to its desired state as quickly as possible. This principle has direct implications for accounting information systems, which, as noted, often provide the measurement function in a feedback control system. A common criticism of accounting reports is that they are not timely, which indicates that perhaps more attention should be given to this factor by designers of accounting information systems.

A third basic principle of feedback control systems is that feedback reports be simple and easy to understand and highlight important relationships or factors requiring the attention of the manager to whom the report is directed. This principle also has implications for accounting systems design. Accounting reports are sometimes criticized for not containing enough information, or for not emphasizing the most important aspects of the process upon which they are reporting. On the other hand, some accounting systems, particularly those which are computerized, may be criticized for providing too much information. A manager who receives a 40 or 50 page report or printout may have difficulty in determining exactly what has been communicated to him. It is thus important that control reports be easy to comprehend and be tailored to the purpose of the control system.

A fourth general principle of feedback control systems is that they be integrated with the organizational structure of which they are part. The boundaries of each process subject to control must be within the span of control of a single manager. That manager must be the one who receives control reports on the process and who has the authority to direct the operations of, and implement necessary changes in, the process. Since he is the one who perhaps best understands the process, he should participate in the formation of the standards against which its performance will be evaluated.

As indicated previously, the functions of a feedback control system in business are roughly to promote operational efficiency and encourage adherence to prescribed managerial policies. These functions are effectively accomplished by means of a reporting system adhering to the general principles outlined above. Feedback reports promote operational efficiency by highlighting inefficient operations requiring management's attention. Furthermore such reports encourage adherence to managerial policies through the knowledge that deviations from such policies and standards are promptly reported.

Feedback Control Systems in Business

Discussion of the principles of feedback control systems underscores the importance to accounting information systems of the concepts of organization and control. To further clarify these relationships some examples of feedback control systems in business will be presented at this point.

Responsibility accounting systems. A *responsibility accounting system* is a system which reports on the achievement of objectives assigned to an organizational unit by a higher level of management. The organizational unit may be designated as either a *cost center,* a *profit center,* or an *investment center.* The objective of

a cost center is to achieve its operational function at a minimum cost, and so reports on a cost center concern only those costs identifiable with its operation. The objective of a profit center is to maximize net profit, and therefore reports on a profit center include both the costs and revenues assignable to it. An investment center has the objective of maximizing return on investment, and so reports on investment centers are concerned with the costs, revenues, and assets identifiable with its operation.

A responsibility accounting system is analyzed here in terms of the five fundamental components of a feedback control system. The process being controlled is the operation which is the responsibility of the organizational unit. The characteristic being controlled may be either cost, profit, or return on investment. The measurement system is the accounting information system, which collects and processes data and reports information in accordance with the organizational considerations discussed in the previous chapter. The regulator of the system is the manager under whose authority the department operates.

The fifth component of a feedback control system is a set of standards or criteria against which the measured state of the process is evaluated. In a responsibility accounting system standards are expressed in the form of a budget. As a basis for developing the budget, many sophisticated manufacturing companies utilize a system of *standard costs*, which are the costs that a given process *should* require under normal operating conditions. Performance reports in such systems emphasize *variances*, or deviations from standard which are identified as to source. Examples of such variances are the materials usage variance, which indicates the difference between actual usage and normal usage of a particular material in a particular operation, and the labor rate variance, which indicates the difference between the actual and normal rates of the employees assigned to a particular task. Standard cost variances of this sort provide a good indication of the corrective action necessary to restore the process to a satisfactory state.

Credit control. The credit control system governs the relationship between a business organization and customers who have purchased from it on credit. The characteristic of this process which is the subject of control is the loss from bad debts. The accounting information system can provide two measures of success for this process. The first of these is an aging of accounts receivable balances, which indicates those customers who have become delinquent in paying their accounts. When such delinquencies reach a prescribed level, the credit manager can act to refuse additional credit to the customer and perhaps initiate special procedures to collect the amount of the existing past due balance. A second measure provided by the accounting system is the total of bad debts written off as uncollectable during a given period. If this total rises beyond an acceptable level, the credit manager might act to tighten policies governing the initial extension of credit.

Inventory control. The process being controlled by an inventory control system is the operation of ordering, storing, and making available when needed within the organization various items of raw materials, parts and supplies, and finished goods inventories. The characteristic being controlled is the balance of each item of inventory. The measurement system is the set of inventory records maintained by the accounting information system. The regulator may be either an inventory clerk or a computer.

The criterion established to control an inventory balance is the *reorder point* for each item of inventory, that is, the level to which the inventory balance must fall before an order to replenish the stock is initiated. The reorder point for each inventory item is established in order to minimize the sum of holding costs and costs of being out of stock. Placing an order to replenish the stock of inventory represents the corrective or regulative action in the system.

In another sense the characteristic being controlled in an inventory system is the sum of the costs of holding and ordering inventory and of stockouts. The characteristics which must be measured in order to achieve this objective include the demand for each inventory item, the *lead time*, or time between order and receipt for each item, the holding cost rate of each item, the cost of placing an order for a batch of each item, and the cost of a stockout of each item. The standards which must be established include not only the optimal reorder point for each item, but also the *economic order quantity*, which is the order quantity of an item which minimizes the sum of holding costs and ordering costs for that item. A simple formula for economic order quantity is as follows:

$$EOQ = \sqrt{\frac{(2)\,(C_2)\,(D)}{C_1}}$$

where C_1 is the carrying cost per unit per year, C_2 is the cost of placing a single order, and D is the demand per year.

Internal audit. The internal audit function was discussed in the previous chapter. Two aspects of this function provide feedback for management control. First, the function of independent appraisal of the performance of various levels of management provides feedback to top management on the effectiveness of subordinate managers. Second, the function of reviewing and assessing the system of preventive controls within an organization provides feedback to accounting executives on the effectiveness of that system. In both cases there are no precise standards or measures of effectiveness, no formula or sum which can easily be determined. Therefore, this type of feedback control system is perhaps more difficult to administer successfully than those described previously.

PREVENTIVE CONTROL SYSTEMS

Whereas feedback control systems regulate processes in which errors or deviations from the norm are expected to occur occasionally, there are certain processes in business organizations in which the occurrence of an error would be quite harmful. It is desirable to design control systems which prevent such errors before they occur. The decision of which type of control system is appropriate for a particular process basically involves a comparison of the average expected loss from the error with the cost of preventing the error. If the occurrence of an error would cause a loss greater than the cost of preventing the error, it is desirable to utilize a control system which prevents the error. On the other hand, if the average expected loss from the error over time is less than the cost of a system which will prevent the error, a feedback control system is appropriate.

Functions of a Preventive Control System

It has been indicated that the functions of a preventive control system correspond roughly to the internal control functions of safeguarding assets and checking the accuracy and reliability of accounting data. Each of these functions is discussed in some detail in this section.

Safeguarding Assets. Any business organization which wishes to remain solvent must concern itself with safeguarding its assets. A significant cause of financial loss to business firms is *embezzlement*, or the fraudulent appropriation of the property of a business by an employee, often accompanied by falsification of records. It has been estimated that losses by business firms from embezzlement approximate $3 billion each year. Such losses are not only costly in terms of the financial loss to the firm, but also in terms of the loss of a productive human resource to the firm and to society. This is true because many embezzlers would never have committed their crime if it were not for the weak control system which encouraged it. Theft of assets by shoplifters, burglars, etc. are other types of losses which control systems must be designed to prevent.

The accounting information system contributes quite effectively to the safeguarding of assets by means of keeping a record of the assets. Discrepancies between the records and the actual quantity on hand can be investigated to discover their source. In the case of cash, the accounting records and the quantity on hand may be compared and brought into agreement weekly or monthly by means of a bank reconciliation. Each individual discrepancy is resolved in this process. In the case of inventories, such a reconciliation typically takes place once annually, when a physical inventory is taken. In most cases tracing of individual differences between inventory records and quantities on hand is impossible, and so trends in the total discrepancy may be used as the basis for relaxing or tightening overall control policies.

Safeguarding of assets is also accomplished by close supervision of asset handling operations and physical protective measures such as limited access

storage areas and plant security forces. These are not strictly accounting functions, although they may be under the authority of the accounting executive in some businesses. However, the accounting system provides information which is useful in evaluating the effectiveness of such controls. The accounting information system thus plays a central role in safeguarding assets in business, as well as nonbusiness organizations.

Internal check. The function of checking the accuracy and reliability of accounting data in a system is referred to as *internal check.* This function is obviously compatible with the functions of recording and processing data. Internal check is a form of verification and is often accomplished through utilization of the maxim of the double entry accounting system that debits must equal credits. Payroll processing provides a good example of this form of internal check. Debits in a payroll entry are allocated to numerous inventory and/or expense accounts. Credits are allocated to several liability accounts for taxes, insurance, union dues, as well as the liability to employees. At the end of this complex operation, the comparison of total debits to total credits provides a powerful check on the accuracy of the process. Any error will create a discrepancy, which will initiate action to discover and correct the error.

Internal check is also accomplished in the processing of data in batches. This is accomplished by means of *batch totals,* or *control totals,* which are sums of a numerical item accumulated from all documents in a batch. Batch totals are typically established at the point of initial formation of a batch, and then checked at various stages in processing to control against loss of records or errors in data transcription.

Errors and inaccuracies in accounting data can have harmful effects upon the relationship of a business to all of the major external parties with which it deals. Such errors may also damage the effectiveness of internal management, which relies upon accounting information as a basis for decision making. In many respects the prevention of loss of assets is closely related to the maintenance of accurate and reliable records, since the latter will contribute a great deal to the former. The remainder of this chapter will discuss the essential elements of preventive control systems and describe some common examples of such systems.

Essential Elements of Preventive Control Systems

Sound organizational practices. Perhaps the most essential factor in safeguarding assets is a sound plan of organization. The responsibility for the security of each type of asset must be clearly established. The principle of organizational independence requires that the function of custodianship of an asset should be under a separate authority from record keeping relating to that asset, and that both of these functions should be separate from any other operating function which utilizes that asset. In a system which incorporates an effective separation of duties among employees, it should be almost im-

possible for any single employee to successfully commit embezzlement. In such a system *collusion,* or conspiracy of two or more persons to commit fraud, may still be possible, but a well-designed system can minimize the chances of successful collusion.

Sound personnel practices. Both the safety of assets and the reliability of accounting records are affected by an organization's personnel policies. The qualifications established for each job designation in a company should reflect the degree of responsibility associated with the position. Qualifications for responsible positions may include a level of experience, intelligence, character, dedication, and capacity for leadership. Training programs should be carefully planned to familiarize new employees with their responsibilities. Policies with respect to raises in salary and promotion are very important, and can be a powerful force in encouraging efficiency and loyal service. For employees in positions involving direct access to property, fidelity bond coverage is important. A *fidelity bond* is a contract with an insurance company which provides a financial guarantee of the honesty of a named individual.

Written guides to policies and procedures. Closely related to sound organizational and personnel practices is the need for manuals of policies and procedures. Such manuals should describe in detail the responsibilities of each individual position in the organization. For this reason they are useful in training new employees. Such manuals should also give an overview of the functioning of the system with respect to each type of transaction, so that the relationship of one employee's functions to others is clear. Such manuals should also contain a detailed listing of the chart of accounts, in order to facilitate the accurate initial recording of transactions. Other instructions for filling out forms used in processing are also important.

Systems and procedures manuals encourage uniformity in data processing and financial operations, thereby preventing the confusion and inefficiency which would result from unnecessary inconsistencies. For example, automated data processing systems require input whose form and content is rigidly specified. If a manual describing the required form and content is available to the various individuals who provide a particular type of input to the system (perhaps salesmen or production workers), the problems of jumbled or incomplete input can be minimized. The use of such manuals in employee training programs also contributes to consistency of practices within the organization.

Physical protection of assets. An important factor in the safeguarding of assets is an adequate program of physical protection. Access to cash should be limited to responsible employees. Cash sales should be controlled by the use of cash registers. Important documents or records should be stored in limited access file cabinets or perhaps a safe. Access to inventory storage areas should be limited. Plant facilities should be protected during nonoperating hours by means of watchmen, burglar alarms, and other safeguards.

Well designed documents. Documents which are carefully designed and effectively used can contribute greatly both to the safeguarding of assets and to the accuracy of records. Source transaction documents should be designed to facilitate the collection of all necessary information with respect to the transaction. Documents which initiate a transaction should contain a space for the authorization of the person or persons charged with that responsibility. Transfer of responsibility for assets from one department to another should be recorded in order to enable the pinpointing of responsibility for any subsequent shortages. Document design should also be simple so that processing can be as efficient as possible. The document format should facilitate review and verification.

An important practice with respect to the design of any document used for control purposes is the sequential prenumbering of all documents. This practice makes it possible to account for and review every document used in a process. Any missing document would create a missing number in the sequence. This practice reduces the likelihood of fraudulent use of documents by dishonest employees.

The record-keeping system throughout a business organization should be well coordinated in order to facilitate the tracing of individual transactions through the system. The path which a transaction traces through a data processing system, from source document to summary reports, is referred to as the *audit trail.* The audit trail consists of such things as reference numbers, dates, and names which are recorded in files, ledgers, and journals to facilitate the tracing of these records to source documents or to records in other files. Good audit trails facilitate the correction of errors and the verification of output information in a system.

Supervision. The availability of supervisory assistance contributes to accuracy of records by reducing the possibility that employees engaged in data processing activities will err in recording situations with which they are unfamiliar. Surveillance of employees who have direct access to assets provides an additional safeguard over such assets. Supervision is especially important as a means of safeguarding assets in businesses which are too small to fully achieve organizational independence.

Examples of Preventive Control Systems

Preventive control systems in business generally are integrated with transaction processing systems. This section will briefly describe some of the most important control features in systems for processing the basic business transactions reviewed in Chapter 1. The emphasis here is on manual rather than automated systems, but the basic control concepts are similar in either type of system. Each of the processing and control systems discussed in this section is described in greater detail in Part Four of this text.

Purchasing of inventory. The basic function of controls in the purchasing function is to assure purchase of all needed inventory items while preventing losses

of inventory. To assure that only items which are needed are actually purchased, initiation of a purchase order should result from the preparation of a formal requisition by a responsible employee in the stores-keeping or production departments. Copies of the purchase order should be furnished by the purchasing department to both the accounts payable department and the receiving department. The receiving department should be responsible for preparing a report listing the quantity of each item received. This report should be signed by an employee of stores to acknowledge the transfer of goods from receiving to stores.

The accounts payable department performs the most significant control function in a purchasing system through its procedure for authorizing payment of vendor invoices. Such authorization is granted only after a review of the purchase order, to assure that the goods were actually ordered, and of the receiving report, to assure that they were received and have been properly transferred to the stores-keeping department. Organizational independence in this process is achieved by separation of the operating function (the purchasing department) from the custodial function (the receiving and stores-keeping departments) and from the recording function (the accounts payable and inventory record keeping departments).

Flow of inventory through production. The primary functions of controls in a production accounting system are to assure production of only those items which are needed and to prevent loss of inventories. The production planning department decides what items will be produced. A good system of reporting on sales trends and finished goods inventory balances is essential to this function.

Control over goods in production begins with the transfer of raw materials from stores-keeping to the factory. This is controlled by documents initiated by the production planning department authorizing the transfer. The production planning or cost accounting department must keep strict documentary control over each batch of work in process as it moves through the factory. Maintaining a record of quantities involved in each transfer of goods from one department to another enables the tracing of any shortage to a single department. The final step in the production process is the transfer of goods to the finished goods storeroom, which is evidenced by a document signed by the finished goods custodian acknowledging receipt of the goods.

Organizational independence in the production function is achieved by separation of the custodial functions (raw material stores, factory departments, and finished goods stores) from the recording functions (production planning and cost accounting). In addition to the system of documentary control outlined above, control over production is also provided by effective supervision on the part of factory foremen and by a program to maintain the physical security of the factory premises.

Payroll. The primary purpose of controls in a payroll processing system is to assure that wages and salaries are paid in appropriate amounts for services properly

rendered. In a typical manufacturing company a record of hours worked for each factory employee is obtained both in the form of clock cards, showing when employees punch in and out, and in the form of job tickets, verified by supervisors and showing the time an employee spent at a particular job. These two input records should be reconciled as an initial step in payroll processing. Job time tickets form the basis for distribution of labor costs to the various inventory accounts representing work in process. Clock cards are used as a basis for the calculation of gross pay, net pay, and various deductions, and for the preparation of paychecks. When these two processes are completed, the total amount of payroll computed in one should be compared with the other as a check upon the accuracy of both.

In processing payrolls for office employees or in a nonmanufacturing company, the supervisor's function is even more significant in providing input to payroll processing. Often the only such input will be a written form listing time worked for each employee prepared by a supervisor, though time clocks may also be used in some cases. For salaried employees the weekly or monthly salary is constant, and so control over input data is not needed unless extra pay is provided for overtime work.

Records of employment, rates, and authorized deductions for each employee should be maintained by the personnel department as well as by the department responsible for preparing checks. All changes in these records, including hirings and terminations as well as rate changes, should be authorized through the personnel department. Organizational independence in payroll processing is achieved by separation of the personnel, payroll preparation, and timekeeping functions. The function of disbursing paychecks should also be separate from the function of preparing them. A separate bank account for payroll only is also a desirable control feature because it facilitates the subsequent preparation of bank reconciliations.

Sale of products. Nearly all transactions between companies are on account, and so problems of handling cash do not arise. The primary functions of controls in a sales order processing, billing, and accounts receivable system are to assure that all sales of finished goods are properly recorded, to prevent loss of finished goods inventories, and to facilitate the collection of accounts. Toward these ends, shipments of goods are not approved until the credit of the customer has been approved. Transfer of goods from the finished goods storeroom to the shipping department must be authorized by documents evidencing a sale. The shipping department must acknowledge receipt of the goods and notify the billing department once the shipment is made. The billing department then prepares the invoice from the original sales order and the documentation supplied by the shipping department. After the invoices are prepared and copies are mailed to the customer, they are posted in batches to the accounts receivable ledger, with batch totals being used to control the accuracy of posting. The accounts receivable department may prepare and send to each customer a periodic statement of his account.

Cash receipt and disbursement. The basic purpose of controls in systems for processing cash receipts and disbursements is to prevent loss of cash. With respect to sales of merchandise for cash by a retail store, the primary controls are good supervision and the use of a cash register. The cash register has several control features, one of which is an internally stored record of each transaction recorded on it which is locked inside the machine to prevent its alteration by the operator. Another control is the use of sales slips which are prenumbered in order that each department may be required to account for all sales slips. At the end of each day, an internal check on cash sales may be performed by comparing the total of all cash sales slips with the total recorded on the cash register tape.

With respect to receipt of payments on account, it has been noted that nearly all such payments are made by check. Control over these receipts typically begins in the mail room where they are opened, recorded, and batched. If customers are requested to return a copy of the invoice or other document indicating the amount of the payment enclosed, an independently prepared record of each payment is obtained. Close supervision provides additional control over the mail opening function.

The cashier's department is responsible for endorsing and depositing checks. The accounts receivable department posts the records of payment to individual accounts. The batch total established in the mail room provides a control over both of these processes. Additional control is provided by the preparation of a bank reconciliation by the internal audit department. Organizational independence is achieved by separation of the functions of opening incoming mail, posting to customer accounts, endorsing and depositing checks in the bank, and preparing a bank reconciliation.

One form of embezzlement involving cash receipts is called *lapping*. In order for an employee to do this he would have to be responsible for both depositing checks and maintaining the record of accounts receivable. Lapping involves concealing a cash shortage by means of a series of delays in posting collections of accounts. The employee would cash a check received from a customer and keep the cash, neglecting to make the entry debiting cash and crediting accounts receivable. Since the customer's account balance cannot be left in error for too long, the employee credits the balance of the first customer upon receiving a check from a second customer. This corrects the first customer's balance, but leaves the second in error. This process of falsifying one customer's account to correct that of another must be continued indefinitely if the shortage is to be concealed.

In companies which are too small to prevent lapping by separation of functions, it can be prevented by an agreement with the bank that no checks made out to the company will be cashed but must be deposited in the company's account. A bank can also help to provide control over a company's cash receipts in other ways. For example, many firms use a "lock box" collection system in which customers are requested to mail payments on account to a post office box. The bank empties the post office box daily, deposits the payments re-

ceived in the customer's account, and provides the customer with a record of the receipts. Though not appropriate for all firms because of its cost, such a system not only provides a good control over receipts but also provides faster deposit of collections and faster notification of checks drawn on insufficient funds.

With respect to cash disbursements, it is essential that the function of authorizing payment and recording accounts payable be separated from the function of writing checks. Many firms use a system in which the assembly of documents supporting a disbursement is followed by the preparation of a *voucher,* which summarizes the data relating to the disbursement and represents final authorization of payment. The person writing checks should examine the voucher and other supporting documents provided by the payables clerk prior to making the check, and should stamp "paid" or some other notation on the supporting documents to prevent them from being used more than once. Further control is provided by having a second person examine the supporting documents and sign the checks. The function of preparing the bank reconciliation should also be performed independently of authorizing payment and signing checks.

In many organizations it is convenient to be able to make some small disbursements in cash in order to avoid the delay and inconvenience of the voucher and check preparation procedure. In such cases it is often appropriate to establish a petty cash fund from which small disbursements of cash may be made. For control purposes it is best to limit the size of disbursements which may be made from the fund, and to require its custodian to obtain a receipt for every disbursement made. The total amount of the fund should be maintained at a constant sum in order that the total of all receipts and cash on hand is equal to the fund total at all times. Responsibility for the fund should be assigned to one person only and not separated. Checks to replenish the fund should pass through the regular voucher procedure, and supporting documentation in the form of all petty cash receipts should be required for such checks.

REVIEW QUESTIONS

1. Define the following terms:

control (two meanings)	reorder point
internal control	lead time
feedback	economic order quantity
cybernetics	embezzlement
responsibility accounting systems	internal check
cost center	batch totals
profit center	control totals
investment center	collusion
standard cost	fidelity bond
variance	audit trail
	lapping
	voucher

2. In the definition of internal control, what is meant by "plan of organization" and "coordinate methods and measures?"
3. Distinguish two general types of control systems. Relate this distinction to the definition of internal control.
4. What are the five fundamental components of a feedback control system and how are they related?
5. In what respect is a feedback control system a self-regulating system?
6. How do feedback control systems in business operations differ from mechanical feedback control systems such as the thermostat?
7. What are four essential factors in the successful operation of feedback control systems in business? Which of these have direct implications for accounting systems?
8. How do feedback control systems in business operate to promote operational efficiency and encourage adherence to managerial policies?
9. What are four examples of feedback control systems in business? Describe the operation of each.
10. What determines whether a particular process should be regulated by a feedback control system or by a preventive control system?
11. Explain in general terms how an accounting system uses preventive controls to contribute to the safeguarding of assets.
12. Describe two examples of preventive control through internal check.
13. Describe six essential elements of preventive control systems in accounting processes.
14. Explain how sequential prenumbering of documents adds to control.
15. Describe the nature of preventive control systems in business relating to the functions of

    a) purchasing of inventory
    b) flow of inventory through production
    c) payroll
    d) sale of products
    e) cash receipts, and
    f) cash disbursements.

    Indicate the basic purpose or purposes of the control system in each case and, where relevant, describe applications of the principles of organizational independence, control by recorded documentation, batching, physical protection, and supervision.

DISCUSSION QUESTIONS

16. Is it possible for the same process to be regulated by both a preventive control system and a feedback control system? Discuss this question using credit control systems as an example.

17. In small companies organizational independence is sometimes difficult to achieve. What other elements of accounting control take on more importance in such situations?
18. Some people feel that controls in business organizations are dysfunctional in that they create resentment and loss of morale without producing much benefit. Discuss this position.

PROBLEMS AND CASES

19. Explain how prenumbering of documents strengthens internal control in the following situation.

    Waitresses of the Wong-Lee Restaurant prepare the customer's check, which the customer then pays to the cashier. The waitresses are told not to destroy any checks, and if a mistake is made to void the check and prepare another. All voided checks are given to the manager daily.
20. You are employed as the Internal Auditor for the Easy Manufacturing Corporation. Prior to your recent appointment, the company had not employed anyone in this position. To familiarize yourself with the company, you have investigated several clerical operations, and have discovered the following:
    a) The person who opens incoming mail prepares a list of receipts of payments on account which he supplies to the accounts receivable clerk. The mail opener is also responsible for endorsing checks and preparing the bank deposit.
    b) A third individual receives invoices from suppliers, files them by due date, and writes checks to pay the invoices on the due date.
    c) A fourth employee is responsible for the timekeeping function, and each week supplies a record of hours worked by each factory employee to a fifth employee, who prepares paychecks. The former is also responsible for maintaining personnel records and for distributing paychecks to employees.
    d) Only one bank account is used and no bank reconciliation is prepared.

    Which of the above employees could possibly embezzle company funds and how? What changes would you recommend to strengthen the system of accounting controls?
21. The Y Company, a client of your firm, has come to you with the following problem: It has three clerical employees who must perform the following functions:
    (1) Maintain general ledger,
    (2) Maintain accounts payable ledger,
    (3) Maintain accounts receivable ledger,
    (4) Prepare checks for signature,
    (5) Maintain disbursements journal,
    (6) Issue credits on returns and allowances,

(7) Reconcile the bank account,
(8) Handle and deposit cash receipts.

Assuming that there is no problem as to the ability of any of the employees, the company requests that you assign the above functions to the three employees in such a manner as to achieve the highest degree of internal control. It may be assumed that these employees will perform no other accounting functions than the ones listed and that any accounting functions not listed will be performed by persons other than these three employees.

a) State how you would distribute the above functions among the three employees. Assume that, with the exception of the nominal jobs of the bank reconciliation and the issuance of credits on returns and allowances, all functions require an equal amount of time.
b) List four possible unsatisfactory pairings of the above listed functions.[3]

22. The Wise Wholesale Company wishes to establish an inventory control system for Widgets, its best selling item. The demand rate for Widgets is a constant 10 units per day or 3600 per year. The cost of placing an order for Widgets is $50. The lead time is a constant two days, and the holding cost rate is $1.00 per unit per year.

Required:

a) Determine the appropriate standards for an inventory control system which will minimize the sum of the costs of holding and ordering inventories and of stockouts.
b) Identify the five fundamental components of a feedback control system in the above situation. Explain how this system should be designed to conform to the four basic principles of feedback control systems.
c) If the demand and lead time were variable instead of constant, what additional problems would exist in the system?
d) Based upon this example, is the inventory control system strictly a feedback control system, or does it also contain elements of a preventive control system? Explain.

23. Miss Prudence Honeyfeather is responsible for maintaining the accounts receivable ledger for the Perfect Controls Corporation. Twice daily she receives a batch of invoices from billing and posts them as debits to customer accounts. One day she mistakenly posted the amount of $1,007.67 to a customer account, when the proper amount was actually $1,070.67. At the next step in processing, the existence of an error was discovered,

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[3] Question 2, Auditing Section, American Institute of Certified Public Accountants Examination, November 1956, Copyright 1956 by the American Institute of Certified Public Accountants and reprinted with permission.

and a comparison of invoices with amounts posted quickly revealed the account in which the error occurred, and it was corrected.

What procedure or control probably resulted in the discovery that an error existed?

24. The following is a list of duties performed by Mrs. C. Nation for the Quick and Easy Corporation.
   a) Credit sales for the day are totaled and reported to the general bookkeeper.
   b) Collections on accounts receivable for the day are totaled. The checks and an adding machine tape of receipts are turned over to the cashier.
   c) Sales and cash collections are posted daily to the accounts receivable ledger.
   d) A trial balance of the receivable ledger is prepared monthly and the total is compared with the total shown by the general control account.
   e) Statements are prepared and mailed on each account monthly. Accounts not paid by the tenth of the month are followed up with a series of collection notices and letters.
   f) Accounts determined to be uncollectable are reported to the general bookkeeper for write-off of the amount included in the control account.

   The company is considering hiring another person to help Mrs. Nation with her numerous duties. Cite at least two forms of manipulation which could possibly be accomplished by Mrs. Nation as her duties are presently defined. What division of duties between Mrs. Nation and a new employee would you recommend to prevent such manipulation?

25. McClain's lumberyard uses the following procedures in selling lumber to customers:
   a) The customer informs a clerk in the office of the sizes and quantities of lumber he wishes to purchase.
   b) The clerk records the items on a sales document, calculating the total cost, and collects payment from the customer.
   c) Assisted by a yard man, the customer obtains the lumber from the yard and loads it onto his car or truck; or if the purchase is large and the customer wishes, McClain's will deliver the order.

   Required:

   Explain several aspects of the design and usage of the sales document which will facilitate control of cash receipts and inventories by McClain's.

26. The cashier of the Easy Company intercepted Customer A's check payable to the company in the amount of $500 and deposited it in a bank account which was part of the company petty cash fund, of which he was custodian. He then drew a $500 check on the petty cash fund bank account payable to himself, signed it, and cashed it. At the end of the

month while processing the monthly statements to customers, he was able to change the statement to Customer A so as to show that A had received credit for the $500 check that had been intercepted. Ten days later he made an entry in the cash received book which purported to record receipt of a remittance of $500 from Customer A, thus restoring A's account to its proper balance, but overstating the cash in bank. He covered the overstatement by omitting from the list of outstanding checks in the bank reconcilement, two checks, the aggregate amount of which was $500.

List what you regard as five important deficiencies in the system of internal control in the above situation, and state the proper remedy for each deficiency.[4]

27. What principle of feedback control systems is probably being violated in each of the following cases?
   a) A monthly report to the credit manager of the Morgan Company indicated that one of the firm's customers, Shylock Corporation, owed Morgan a large sum of money on account which was over 90 days past due. Morgan's policy is to refuse to sell on account to customers whose account is 90 days or more past due. However, on the day before the monthly report was received, a large order by Shylock has been approved by the credit manager.
   b) Each month the Morgan company provides its factory foremen with a performance report indicating budgeted and actual costs for each foreman's department. Each report contains an analysis of material, labor, and overhead costs. Among the overhead costs are proportionate allocations of the salary of the plant manager and his staff and of depreciation for the plant and equipment. The performance reports are considered to be the single most important tool for evaluating the performance of factory foremen.
   c) A special study indicated that lax control over office supplies in the Morgan Company had resulted in waste amounting to from $100 to $300 per month. As a result a room was set aside to be a supplies storeroom, a clerk was hired to manage the storeroom, and a control system designed around a supplies requisition document was implemented.
   d) Each week the purchasing agent of the Morgan Company is provided with a computer listing of the parts inventory ledger. The purchasing agent determines which parts must be ordered by comparing the quantity on hand with the reorder point on the report for each item. For those items which must be reordered, the agent must go through his catalogs to determine which vendors the part is purchased from, select a vendor, and then prepare the purchase order. Delays in this process have often resulted in stockouts of parts needed in production.

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[4]Question 4, Auditing Section, American Institute of Certified Public Accountants Examination, May 1958. Copyright 1958 by the American Institute of Certified Public Accountants and reprinted with permission.

PART TWO

THE TECHNOLOGY OF INFORMATION SYSTEMS

Chapter 4

Data Collection and Data Processing Systems

The variety of business machines available to assist business organizations in collecting and processing data and generating information is enormous. A partial list includes: computer systems, cash registers, adding machines and calculators, bookkeeping machines, typewriters, microfilm systems, duplicating machines, mail preparation devices, postage meters, punched card equipment, and communications equipment. Each of these categories contains several subcategories and/or a wide assortment of optional features. To attempt to describe all of these various categories, subcategories, and optional features would be impractical. Part Two of this book (Chapters 4 through 7) reviews the basic features of those business machines which have direct applications in accounting.

Computer systems represent the highest form of business information systems, and also the most complex. For these reasons, three of the four chapters in this Part (Chapters 5 through 7) cover computer systems. This chapter surveys a variety of other business machines commonly used in accounting information systems. All of these "other" machines may be and are frequently used by organizations also utilizing computers. Of course, there are many small companies which do not utilize computers at all. Therefore, the machines discussed in this chapter are very important to these small companies because they often represent the only affordable means of mechanizing data processing functions.

Even though this chapter does not specifically discuss computer systems, it does describe several machines which prepare input for computer systems. Along these are devices used for *source data automation* (SDA), which is the collection of source data in machine-readable form at the time and place of origination of the data. Many traditional business machines, such as cash registers and typewriters, have optional features which enable them to be used for source data automation. The primary data recording media used in SDA

are: (1) punched paper tape, (2) documents printed in special characters which are readable by optical scanning devices, (3) punched cards, and (4) magnetic tape. While SDA devices are described in this chapter, the various data recording media are described more fully in Chapter 5.

With respect to the business machines covered in this chapter, the basic purposes of each presentation are to describe and/or illustrate the device itself, to discuss the basic data processing functions which it performs, and to provide examples of its application in accounting information systems.

ADDING MACHINES AND CALCULATORS

These devices have long been favorites of accountants in the performance of calculating, verification, and summarizing functions. Most such machines consist of a keyboard and a screen or roll of paper for displaying or printing results. The adding machine is capable only of addition and subtraction. A common use of the adding machine is to accumulate and/or verify the accuracy of the sums of columns of figures in a ledger or journal. Another common use is to accumulate control totals as batches of documents are processed. The adding machine tape produced in these operations serves as a useful record for purposes of internal check and audit. An illustration of the ten-key adding machine, a very popular device among accountants, is provided in Fig. 4.1.

A calculator is capable of multiplication and division as well as addition and subtraction. Some calculators operate electromechanically, while the more modern ones are electronic (See Fig. 4.2). These machines are naturally applied to functions which require multiplication or division, such as the computation of gross pay in payroll processing or the multiplication of price times quantity in invoice or purchase order preparation. In addition to computation, the calculator is also used for verification and summarization.

Some modern calculators can be programmed to store and execute a series of instructions like a computer. These machines are called programmable calculators, or *microcomputers*. In addition to arithmetic keys, the keyboard of a programmable calculator contains keys with which programming and data storage entries can be made (see Fig. 4.3). Most programmable calculators can store and execute up to several hundred program steps. These devices are useful for problems which are too large for simple calculators, but too small or infrequently occurring to warrant the use of large-scale computers. Many engineering and operations research problems fit this description. In small firms which do not have computers, the programmable calculator is a useful substitute for high volume repetitive tasks involving a series of related computations, such as payroll processing and other accounting operations.

Some adding machines and calculators can be equipped with devices which produce punched paper tape or punched cards as a by-product of their computation function. Thus if an adding machine is used to prepare a batch total of a set of documents, a paper tape may be produced which contains the amount from each document and the batch total. After the documents have been con-

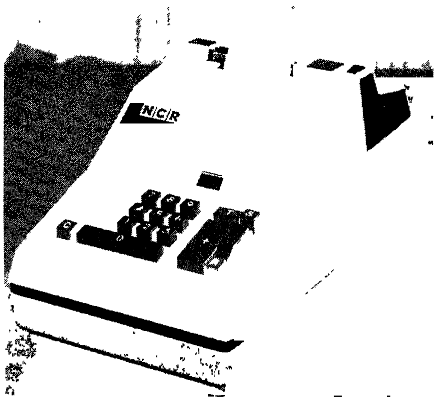


Fig. 4.1 Ten-key adding machine. (Courtesy of The National Cash Register Company.)

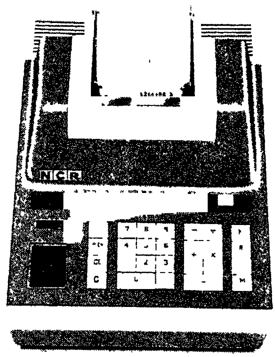


Fig. 4.2 Electronic calculator. (Courtesy of The National Cash Register Company.)

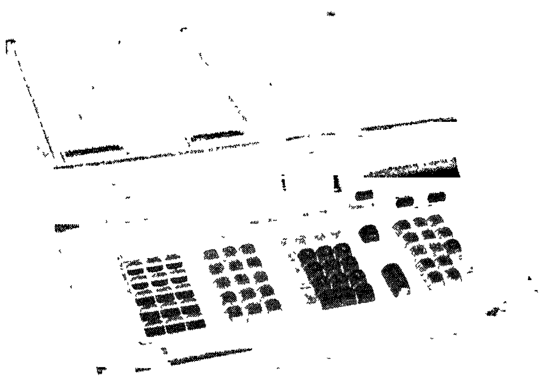


Fig. 4.3 Programmable calculator. (Courtesy of Hewlett-Packard.)

verted to a computer input medium, the paper tape may be read into the computer to check the accuracy of the data on the input medium. This example illustrates the usefulness of such devices for purposes of accounting control.

CASH REGISTERS

As with adding machines and calculators, cash registers may be either electromechanical or electronic in operation. The cash register is almost indispensable to any form of retail business. The typical cash register consists of a keyboard, cash drawers, display window, and receipt imprinter. The cash register per-

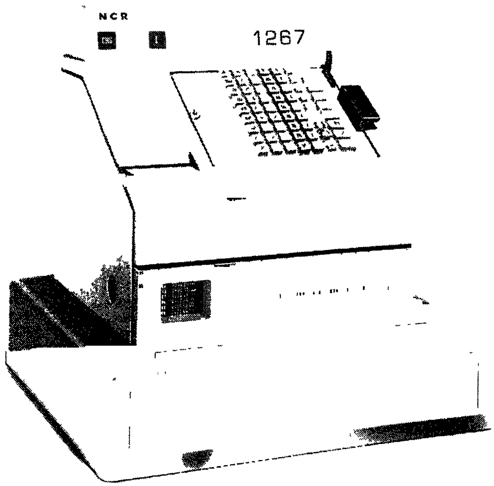


Fig. 4.4 Cash register. (Courtesy of The National Cash Register Company.)

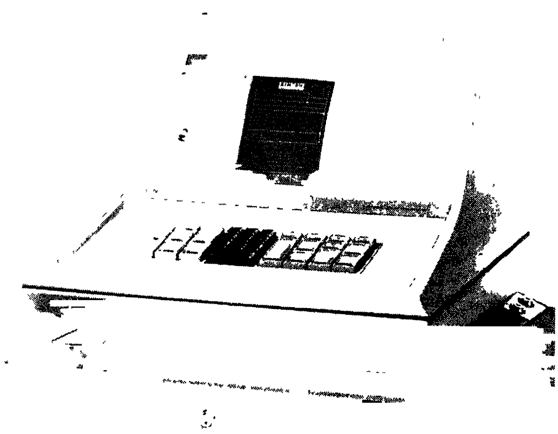


Fig. 4.5 Point-of-sale recorder. (Courtesy, Singer Business Machines.)

forms several data processing functions, including recording, classifying, and summarizing. (See Fig. 4.4.)

A major factor in the usefulness of cash registers is the control which they provide over the recording of cash sales transactions. The bell which sounds

Fig. 4.6 Automatic tag reader. (Courtesy, Singer Business Machines.)

when a cash sale is rung up, and the totals which appear in the display window facilitate supervision of sales clerks. The display window total and customer receipt provide the opportunity for the customer to notice a discrepancy between the amount paid and the amount recorded, which discourages any deliberate errors. Once a sale is recorded, a record of it is printed on a paper tape locked inside the register to prevent subsequent alteration. At the end of a day this internally accumulated total should check with the amount of cash accumulated in the cash drawer. Other available features of cash registers which provide increased control are multiple cash drawers, so that each sales clerk can be made responsible for his own individual cash drawer, and an attachment which dispenses the exact amount of coin change due to a customer.

Some cash registers have a separate set of keys whereby an indication of type of merchandise or department can be made on the tape for each item sold. This feature facilitates the data processing function of classification, providing a basis for subsequent analyses of sales and inventory for planning and control purposes.

Modern electronic cash registers which can be used for source data automation are called *point-of-sale recorders* (see Fig. 4.5). These devices can perform all of the functions of traditional cash registers. In addition they can perform calculations (multiplication or division), which makes them useful for determining discounts or sales taxes. Some have tag readers (see Fig. 4.6) which can read item number and price data from prepunched merchandise tags. SDA media which can be produced by various point-of-sale recorders include punched paper tape and magnetic tape.

In addition to these characteristics, point-of-sale recorders are also capable of being hooked up directly to a computer system. A major advantage of this feature is the capability it provides for checking a customer's credit at the time of a sale. In addition, use of this feature enables quick processing and analysis of cash receipts and inventory data by retail organizations.

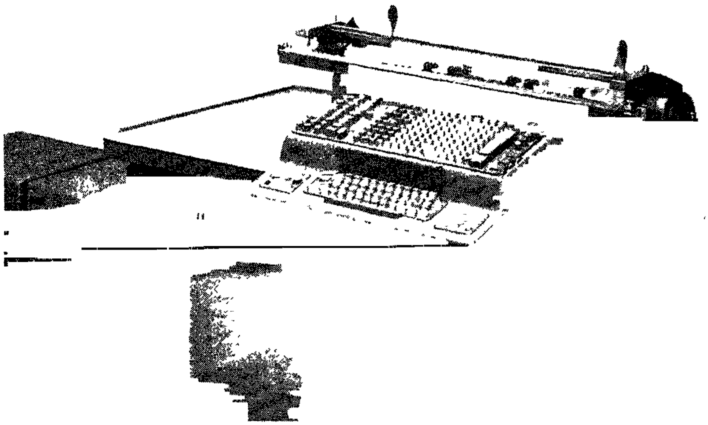


Fig. 4.7 Bookkeeping machine. (Courtesy of The National Cash Register Company.)

BOOKKEEPING MACHINES

These machines, which are also referred to as posting or accounting machines, combine the features of the adding machine and the typewriter and are also capable of accumulating a number of separate totals during use. They consist of a numeric keyboard and sometimes a typewriter keyboard as well, and a carriage and one or more slots which hold the records being processed (see Fig. 4.7). The carriage typically holds a wide roll of paper, while the slots in front are capable of holding a number of forms of varying sizes. A control bar similar to a typewriter tab control is used to assist the operator in spacing for data entry.

In general, bookkeeping machines are primarily useful for performing the data processing functions of transcribing and summarizing. The more advanced ones can also perform calculations. The transcribing function is accomplished by means of simultaneous writing of common data onto multiple documents and forms. This feature greatly minimizes the possibility of transcribing errors and also increases the speed of data processing. The summarizing function is performed by machine memory, which may consist simply of mechanical accumulators or of electronic storage. Numbers accumulated serve as batch totals for control purposes and as the basis for journal entries to control accounts.

Bookkeeping machines are commonly applied to many data processing applications in accounting, including accounts receivable, accounts payable, general ledger, and payroll. To illustrate one possible application, consider a clerk who is responsible for processing batches of vendor invoices which are ready for payment. Such a clerk would be required to write a check for each vendor, enter all transaction data for each payment in the cash disbursements journal, post a debit to each vendor's account in the accounts payable ledger,

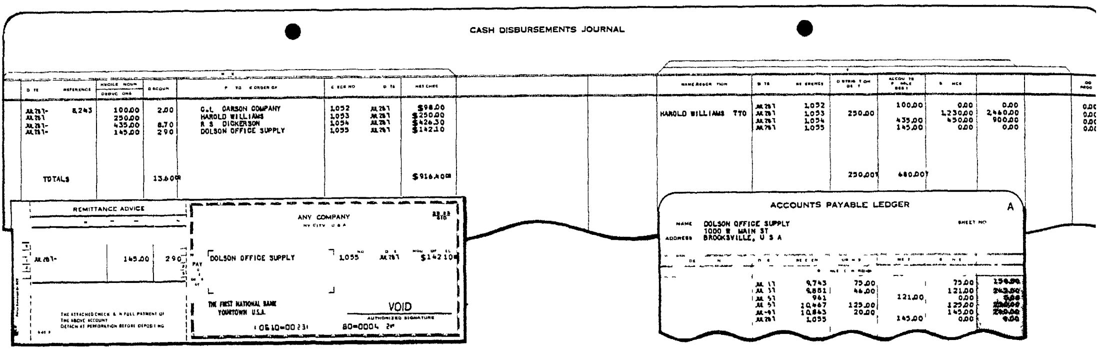


Fig. 4.8 Processing of cash disbursements using a bookkeeping machine. (Courtesy of The National Cash Register Company.)

and initiate a summary journal entry debiting accounts payable and crediting cash.

If a bookkeeping machine were used in this operation, a wide roll of paper in the machine's carriage would serve as the cash disbursements journal. A ledger card drawn from a looseleaf accounts payable ledger would be placed in a slot in front of one side of the journal. A check and check stub would be placed in front of the other side (see Fig. 4.8). The clerk would enter the invoice amount, discount (if any), vendor name, and previous balance in the vendor's account. The machine would automatically provide the date and a check number, and compute the amount of the check. These data would be entered on the check and, by means of carbon copy duplication, also be entered on the cash disbursements journal. In addition the machine would compute a new balance for the vendor's account and print this new balance, along with repeat printing of the date, check number, and invoice amount, on the accounts payable ledger card. This data would be duplicated on the cash disbursements journal as well to provide a detailed record of the debit portion of each entry.

During this processing operation, the bookkeeping machine would be accumulating batch totals of several data items, including gross invoice amount, discount taken, amount paid, account balances prior to posting, and account balances after posting. At the completion of processing, the clerk would utilize these totals to prepare a summary journal entry debiting accounts payable and crediting cash and discounts earned. The updated ledger cards would then be placed back in the accounts payable ledger file, the checks would be mailed, and the cash disbursements journal page would be placed in a bound journal.

Several internal check procedures can be applied in conjunction with the use of bookkeeping machines. Again in terms of the above example, the clerk could have entered the old account balance twice—the second time in a sepa-

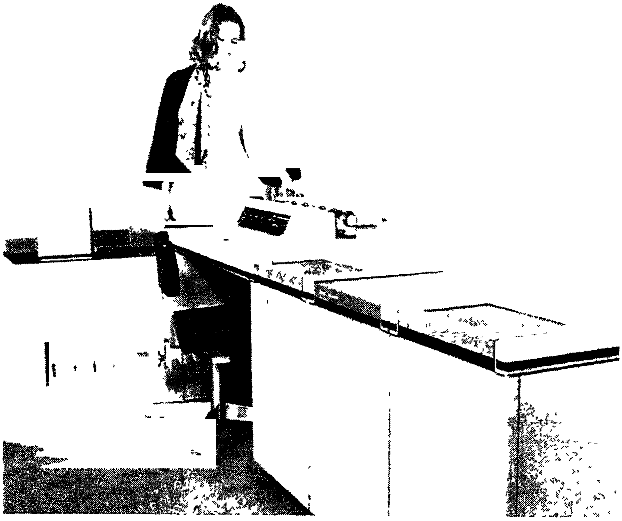


Fig. 4.9 Electronic accounting machine. (Courtesy, Singer Business Machines.)

rate register which accumulates the total of all old account balances. At the completion of processing, the total of all new balances would be subtracted from this total of old balances, and the difference should check with the total amount debited to the accounts payable control account. If these totals do not check, an error may have been made in entering the amount of one or more old balances. A check on the accuracy of recording the amount of each invoice can be made by totaling the amount of the invoices prior to processing, and then comparing this total to the one accumulated during processing. In addition, or alternatively, the invoices can be compared in detail with the amounts recorded in the cash disbursements journal after processing is completed.

In some applications of bookkeeping machines it is necessary to accumulate several totals if, for example, the application involves several debit or credit accounts. To illustrate, consider the process of authorizing vendor invoices for payment, which involves distributing the debit portion to one or more of several inventory and expense accounts. Totals for the accounts having high activity, such as purchases, freight, supplies, or travel, would be accumulated separately, while all entries to less active accounts would be accumulated in a miscellaneous category.

A wide variety of bookkeeping machines with numerous optional features is presently available, with prices ranging from $2,000 to $30,000. One common optional feature is an attachment which prepares SDA media, such as punched paper tape or punched cards. The most advanced bookkeeping ma-

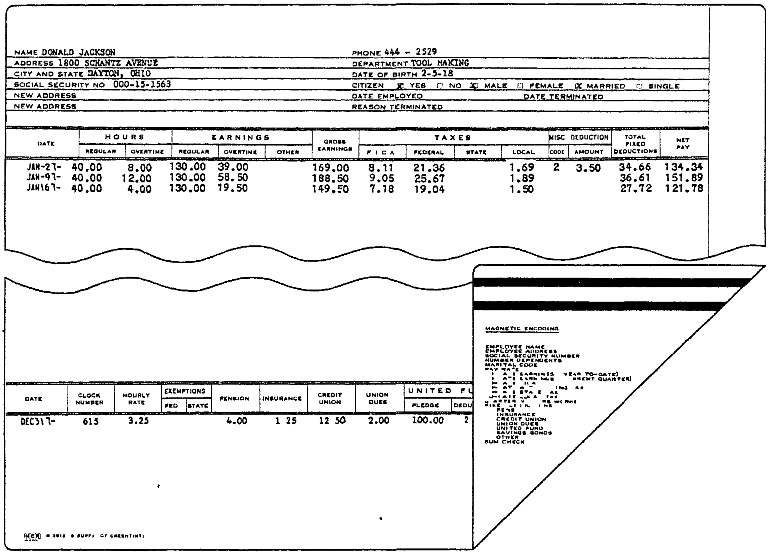


Fig. 4.10 Magnetic stripe ledger record. (Courtesy, The National Cash Register Company.)

chines possess many of the features of computer systems, including electronic memory, arithmetic and logical ability, punched card or punched tape input and output, and a capability for storing and executing small programs. Such machines are referred to as electronic accounting machines. An example is shown in Fig. 4.9.

Several electronic accounting machines incorporate the feature of magnetic stripe ledger records (see Fig. 4.10). The magnetic stripes on the reverse side of these records can be encoded with file data such as account numbers and balances or employee payroll data. When the ledger card is inserted into the machine, this data is read from the magnetic stripes. The operator then keys in the data to be posted to the ledger and the machine prints this information and accumulates an updated ledger balance. The new balance is printed on the front of the ledger and is also encoded on the magnetic stripe.

OTHER SOURCE DATA AUTOMATION DEVICES

Thus far it has been indicated that source data may be captured automatically as a by-product of the operation of adding machines, calculators, cash registers, and bookkeeping machines. Some other commonly used SDA devices include: the portable data recorder, the embossed-card imprinter, and the automatic typewriter. Each of these devices is examined briefly in this section.

The designation of portable data recorder encompasses a variety of SDA devices which are small and lightweight and therefore easily carried to the point of origin of source data. Such devices are useful for applications in which

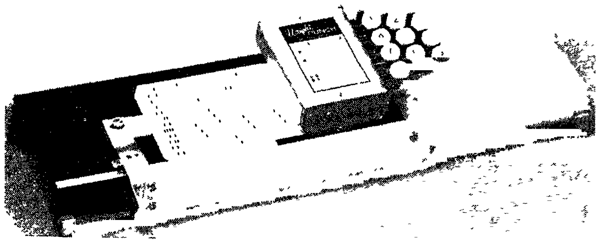


Fig. 4.11 Portable data recorder. (Courtesy of Wright Line.)

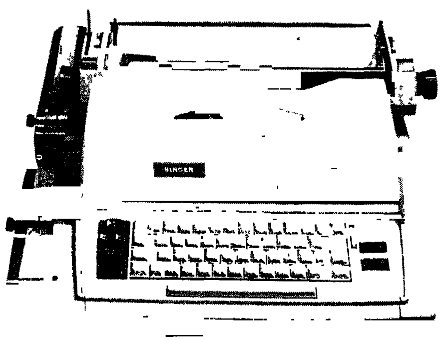


Fig. 4.12 Automatic typewriter. (Courtesy, Singer Business Machines.)

the points of origin of source data are widely separated and the volume of source data from any single location is not sufficient to justify a stationary device. Examples include the collection of meter readings and the taking of physical inventories. The most popular portable data recorders are ones which produce punched cards, though devices which prepare punched paper tape and magnetic tape are also available. An example of a portable data recorder is illustrated in Fig. 4.11.

Embossed-card imprinters should be familiar to almost everyone who uses a credit card. These devices are used to imprint raised characters from plastic cards or metal plates onto paper forms. A carbon process is commonly used to accomplish the imprinting, with pressure applied by a manually operated bar or lever. Some of these devices permit the entry of variable data, such as price or item number, in addition to the fixed customer data on the cards. The primary advantage of embossed-card imprinters is the quick and accurate preparation of legible source data which they provide. In many applications the forms produced are not used as input to automated processing. However, embossed-card imprinters can be made to produce documents which can be read by optical

character recognition. The most familiar users are the national credit card organizations and the large oil companies.

The automatic typewriter consists of a regular electric typewriter with attached input and output units. The input unit allows data to be read from a medium such as punched tape or cards and simultaneously typed. The output unit enables the creation of a machine-readable record of any document prepared on the typewriter. An example of an automatic typewriter is illustrated in Fig. 4.12.

Automatic preparation of machine-readable source data is only one useful function of the automatic typewriter. The input unit also enables faster and more accurate typing in high-volume applications by means of automatic entry and typing of constant data. For example, in a billing operation a file of punched cards may be used, each of which contains the account number, name and address, shipping arrangements, and billing terms for a customer. When a customer invoice is prepared on the typewriter, the appropriate card may be pulled from the file and inserted into the input unit, causing the customer data to be automatically typed on the invoice. Variable data, such as items sold, quantities, prices, etc., would then be entered manually. Other common applications of the automatic typewriter include the preparation of form letters and of purchase orders.

MICROFILM SYSTEMS

The use of microfilm in business data processing is becoming increasingly popular. Whereas microfilm was formerly considered to be a method of storing inactive records for legal and tax purposes, it is now commonly used to maintain current records as well.

The equipment in a typical microfilm system includes: (1) a microfilm camera, which photographs documents or reports and develops the film; (2) a processor, which organizes the film in one of several forms; (3) a reader-printer, which reads and displays on a screen the images on microfilm and produces paper copies if desired; and (4) a system of storage and retrieval of the microfilm. In addition many systems include equipment for preparing microfilm as computer output (See Chapter 5).

A microfilm camera includes a mechanism for automatic feeding of documents to be filmed (see Fig. 4.13). Operating speeds of these devices range up to 600 documents per minute. They produce a roll of film 16 or 35 millimeters in width, containing up to 3,000 8½ by 11 documents. Microfilm may be stored in roll form, or it may be converted by special processors to one of several other forms, including cartridges, special punched cards called aperture cards, or microfiche or jackets, in which a set of related documents are included on a single sheet of film. Each of these various forms of microfilm storage is illustrated in Fig. 4.14.

A microfilm reader-printer is illustrated in Fig. 4.15. It consists of a device for inserting and reading microfilm in one or more of the forms described

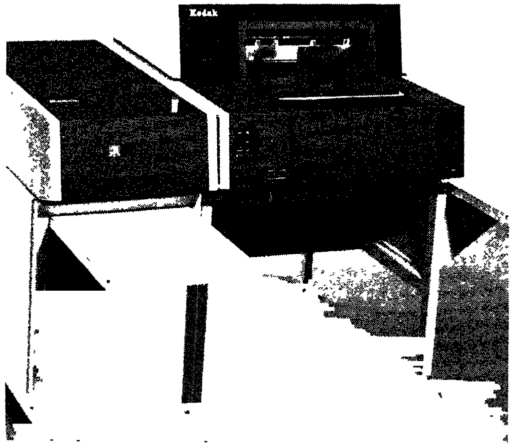


Fig. 4.13 Microfilmer (right) and microfilm processor (left). (Courtesy of Eastman Kodak Company.)

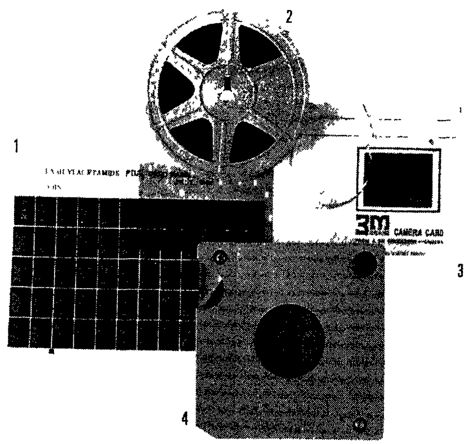


Fig. 4.14 Some alternative forms of microfilm storage: (1) microfiche, (2) roll, (3) aperture card, and (4) cartridge. (Courtesy of Minnesota Mining and Manufacturing Company.)

above, a display screen, and a unit which produces a paper copy of the screen image at the push of a button.

A microfilm storage and retrieval system may consist simply of specially designed filing cabinets for manual retrieval, or it may consist of special equipment which enables immediate access to selected records in large files. Systems of the latter type include a keyboard and screen for request and display of the records desired, and a file storage unit with the capability of automatic retrieval

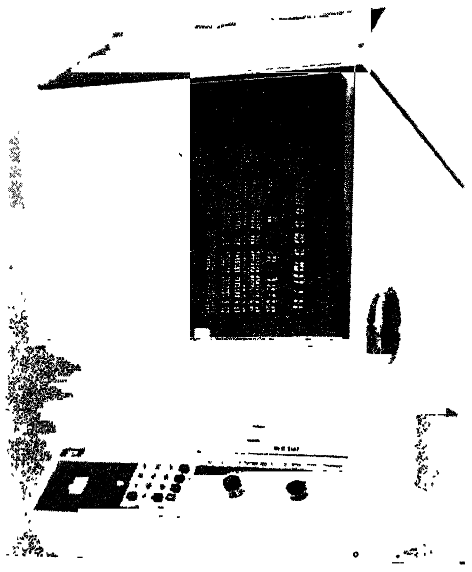


Fig. 4.15 Microfilm reader-printer. (Courtesy of Minnesota Mining and Manufacturing Company.)

of records on microfiche or aperture cards. Many systems also incorporate a printer which can be used to prepare a hard copy of any desired record. These systems enable access to a single record within a file of thousands in a period of only a few seconds.

The most obvious advantage of microfilm systems is that they reduce space requirements for records storage from 95 to 99% or more. In addition, they provide savings in handling and distribution of records. Microfilm itself is less expensive as a storage medium than paper. Records on microfilm can be retrieved faster than those on paper documents stored in filing cabinets, particularly if automatic retrieval systems are used.

The primary disadvantage of microfilm systems is the cost of the required equipment, which limits its application primarily to high-volume situations. In addition, microfilm is not an appropriate storage medium for records which must be frequently updated. Examples of common applications of microfilm systems in accounting and related areas include the retention of charge sale documents or invoices by retail or industrial firms, retention of documentation supporting cash disbursements, and the retention of copies of depositors' checks by banks.

PUNCHED CARD DATA PROCESSING SYSTEMS

A punched card data processing system is a group of related machines which in total is capable of performing virtually all data processing functions using the punched card as a medium. Eight basic punched card machines, each of which performs a different set of functions, are discussed in this section. Although these machines can serve as the basis for a complete automated data processing system without a computer, this type of usage is dying out, and the main usage of punched card machines today is as auxiliary equipment in card-oriented computer systems.

The first punched card machines were invented in the 1880's to meet the need for processing the huge quantities of data associated with the United States census of population. The inventor was a Census Bureau statistician named Herman Hollerith. Hollerith later founded the Tabulating Machine Company, which after several mergers, changed its name in 1924 to the International Business Machines Corporation. This company, commonly known as IBM, has been the leader in the manufacture of data processing equipment since its foundation.

Punched card data processing is based upon the *unit record concept,* whereby all data regarding a particular subject or transaction is recorded on a single document, the punched card, which then serves both as a storage medium and as input to all subsequent processing operations. Figure 4.16 illustrates the standard 80-column punched card, showing the standard hole pattern for numeric, alphabetic, and selected special characters. The unit record concept and its application through punched card data processing provides the advantages of increased speed of processing, elimination of duplication of effort in preparing and transcribing input data, more efficient data storage, and lower cost per item processed than less advanced facilities and techniques.

Though punched card equipment is becoming obsolete as a total data processing system, the punched card itself continues to thrive as a basic input medium to computer systems. IBM introduced in 1969 a 96-column card approximately one-third the size of the 80-column card for use in its small computer systems. Many firms continue to manufacture and sell card preparation and card processing equipment for both the 80-column and 96-column card. Though more advanced means of data preparation are available, the number of keypunch units presently in operation is estimated at more than 500,000 and is still growing.

A popular use of punched cards, and one which helps to explain their predominance as a computer input medium, is as *turnaround documents.* These are documents which are produced in machine-readable form as the output of an automated system, are used as a record in a external process, and are then returned to the system as an input record of the external process. An example is the punched card which many utility companies send out as a bill with the request that the card be returned with the payment. Since turnaround docu-

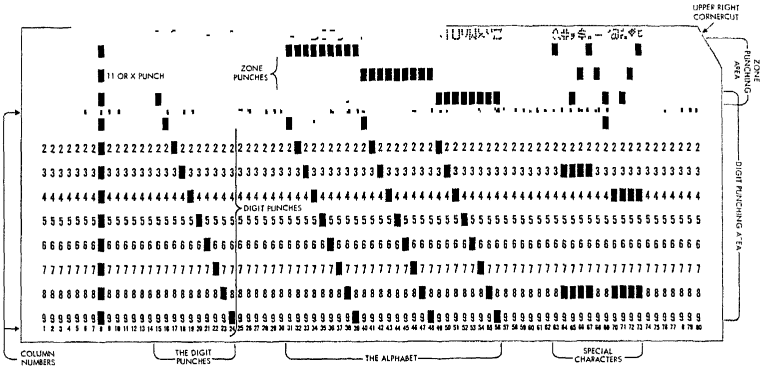


Fig. 4.16 80-column punched card. (Courtesy of International Business Machines Corporation.)

ments are originally produced automatically, their use reduces the volume of input preparation work and also reduces the possibility of errors in the input data.

The Keypunch and Verifier

The primary machine for producing punched card input is the familiar keypunch. This machine uses a typewriter keyboard to initiate the punching of holes in cards and also the printing of data across the top of the card. It is assumed here that the reader is familiar with the features and operation of the keypunch. If not, a detailed explanation can be found in other sources.[1]

The verifier is quite similar in appearance to the keypunch, and performs the function of verifying the accuracy of data already punched in a card. The machine is operated in the same way as the keypunch, except that instead of punching holes the machine checks the holes already in the card for agreement with the keys being punched. If a particular character is in error, a light comes on and the card is locked in place. The operator then checks the source document and again depresses the appropriate key. If the verifier operator made the error, the card will continue through after this correction, whereas if the card is in error this step will again activate the light and lock the card in place. After a third attempt by the operator, the card is notched by the verifier at the top of the erroneous column and permitted to advance. If a card contains no errors, it is notched on the end by the verifier. After a batch of cards is verified, the notches permit easy identification of errors for subsequent correction.

[1]See for example Clarence B. Germain, *Programming the IBM 360* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967), pp. 3-6.

Although this form of punched card verification may seem costly and time-consuming it is justified in that all subsequent processing steps are automated and offer little opportunity to find and correct errors. A single punched card may be used as input to several different processing operations, and if the card were in error, the output of each operation would also be in error. The time lost in card verification is more than made up for by the time saved due to the speed of punched card processing machines and computer systems.

Keypunching and verification represent a major portion of the cost of a punched card data processing system. Even in a card-oriented computer system the cost of data preparation may be up to 40% of the total operating costs of the system. This is true because data preparation is the only major function in an automated system which makes extensive use of human labor, with its limitations in speed and reliability. However, there are means of controlling the level of data preparation costs which, if properly applied, can result in significant reductions in this cost for many firms.

One means of controlling data preparation costs is performance measurement and evaluation. This method involves setting a standard performance rate for all keypunch and verifier operators. One standard unit of measure for such work is keystrokes per hour. Once the appropriate standards are determined, a schedule of work can be established, with each job scheduled to consume a total time determined in accordance with the standards. The performance of the data preparation department can then be evaluated in terms of whether it meets its schedule. The performance of individual operators can also be measured and evaluated in terms of the standard, with raises and promotions being based on superior performance.

Several further methods of improving performance in data preparation are worth mentioning. One relates to data verification. It is seldom necessary to verify 100% of all input data. For example, names and addresses, inventory descriptions and other alphanumeric data do not require key verification. Numeric data which is used only for reference and not in processing may not require verification. Restriction of verification to only critical data, such as identifying numbers and transaction amounts, may often result in significant savings of data preparation costs.

Efficiency may also be improved by proper design of the formats of source documents and punched cards. Punched card formats should correspond to source document formats in terms of the sequencing of data to ensure that keypunch and verifier operators can read the source document easily while punching, without having to transfer vision from side to side or top to bottom and back again. Furthermore, the card format should minimize the necessity for skipping of spaces by keypunch or verifier operators. For example, no blank spaces should be left between individual items of data in the card format. Still another means of improving efficiency is for certain data which is the same on all cards in a batch, such as the date or batch number, to be prepunched on all cards by another machine which can do the job automatically.

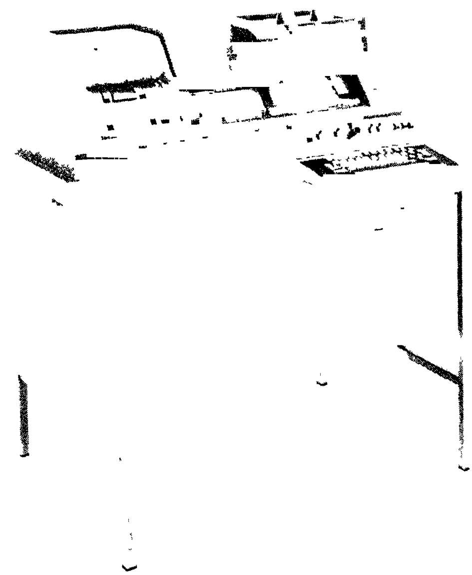


Fig. 4.17 Buffered keypunch. (Courtesy of International Business Machines Corporation.)

The opportunity to improve the efficiency of data preparation has been the primary factor behind the success of the buffered keypunch, an advanced keypunch recording device first introduced in 1968. An example of a buffered keypunch is illustrated in Fig. 4.17. The machine looks quite similar to a regular keypunch. The difference is that the buffered keypunch has an electronic "buffer" memory in which data entered by the operator is stored until all data for a card is entered. The machine then automatically punches the card from the data stored in memory while the operator keys in the data for the next record. One advantage of this approach is that if the operator makes an error in keypunching, it can be corrected in the memory prior to punching the card, which eliminates the necessity for repunching of cards. Another advantage is that skipping of spaces within a card is accomplished electronically rather than mechanically, which further improves the speed of keypunching and verification. Finally, buffered keypunches are multifunction machines in that they may be used to perform both keypunching and verification.

The Card Sorter

This machine illustrated in Fig. 4.18, performs the function of arranging cards in numerical or alphabetical sequence. The sort operation is performed on one column of the punched cards at a time, with each card being deposited by the sorter into one of thirteen pockets in the machine. The thirteen pockets correspond to the twelve rows in which a hole may be punched on a card, with

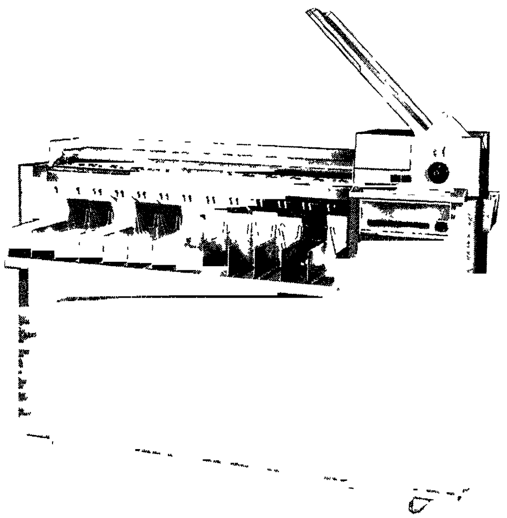


Fig. 4.18 Punched card sorter. (Courtesy of International Business Machines Corporation.)

the thirteenth pocket receiving cards in which no hole is punched. To sort cards into sequence by a four digit number requires four consecutive sorts, one for each digit, starting with the digit farthest to the right. The card column on which the sort is desired is set by the operator by means of a cóntrol switch. Because alphabetic characters are represented on punched cards by means of two holes in each column instead of just one, an alphabetic sort requires twice as many separate sorts as a numeric sort on an item with the same number of characters.

The sorting function is one of the primary activities in the processing stage of the data processing cycle. It is of particular significance in accounting work because many types of accounting records, such as an accounts receivable subsidiary ledger or an inventory file, are stored sequentially, and the efficient updating of such records requires that transactions be sorted into the same sequence prior to processing. The importance of this function makes a high speed sorter a very useful device to an accounting information system. Processing speeds of typical card sorters range from 650 to 2,000 cards per minute.

In addition to sequencing, a sorter can be used to perform the functions of grouping, or assembling items into various categories based upon their characteristics, and selection, or extracting items of a particular type from a set of records. The grouping operation is useful to the processing activity of analyzing. An example related to accounting would be the analysis of production costs, which involves grouping cost items by department, by type of cost, or by level at which effective control is exercised. As explained in Chapter 2, the coding device used for this form of analysis would be the chart of accounts. The selec-

tion operation is related to the data processing activity of comparing and is useful in the application of the principle of management by exception. Selection is generally performed by the sorter only if the field used as a basis for selection is a one-digit field. Examples relating to accounting include the selection of all customers located in Territory 6 from a file of customer accounts, or the selection of all employees in Division 3 from a payroll file.

The Tabulator

This machine, also referred to as the accounting machine, is the element of a punched card system which is most responsible for the communication of output from the system. The tabulator prepares printed reports from punched cards, and is also capable of adding, subtracting, and accumulating totals. An example of a punched card tabulator is illustrated in Fig. 4.19. The specific operations performed by a tabulator during a particular processing task are controlled by a wired control panel. These control panels are easily interchangeable so that a separate one can be prewired to perform each separate procedure for which the tabulator is used in a system.

Many accounting operations involve the accumulation of totals, the updating of files, and the printing of documents and reports. Thus the high speed tabulator can be very useful to an accounting information system. Tabulators are available which will add, subtract, and print at speeds of 100 to 150 lines per minute.

The Collator

The punched card collator, illustrated in Fig. 4.20, is capable of performing several data processing functions. This machine has two input hoppers to accept two separate decks of cards, and four or five pockets for processed cards. The functions it performs include the merging of two separate decks ordered in the same sequence into a single deck, checking the sequence of a previously sorted deck to verify the accuracy of the sort, selection, and matching. In the process of selection the collator, unlike the sorter, can use a field having several digits as a basis for selection from a file. For example, all accounts having a balance in excess of $2,000.00, or having a due date prior to 74/12/01 could be selected from an accounts receivable file in a single pass on the collator.

In the matching operation, as in merging, the input consists of two decks which are ordered in the same sequence. In matching, however, the objective is to produce two decks, each of which contains all cards in one input deck which have the same number as one or more cards in the other deck. These two matched decks are placed in the two primary output pockets. All cards from each deck which are unmatched with one or more cards in the other deck are placed in two secondary output pockets. The match and merge operations may also be combined, with all matching cards from the two input decks merged into a single output deck and all unmatched cards placed in two other output pockets.

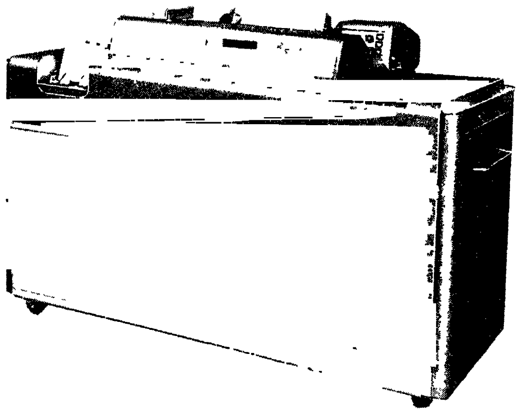


Fig. 4.19 Punched card tabulator. (Courtesy of International Business Machines Corporation.

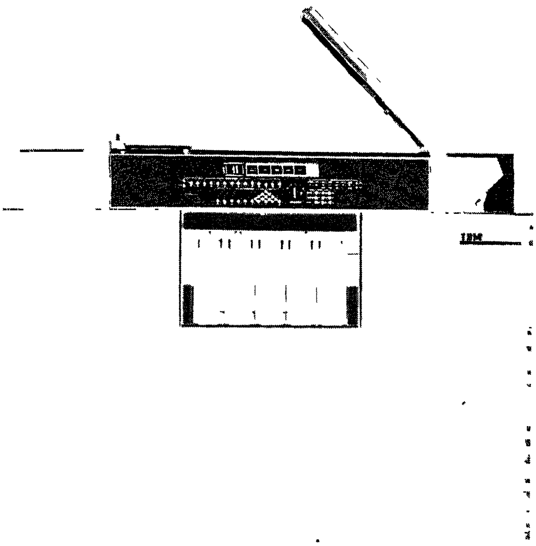


Fig. 4.20 Punched card collator. (Courtesy of International Business Machines Corporation.)

Operations performed by the collator, as with the tabulator, are controlled by interchangeable wired control panels. Since the collator's main functions are performed on sequential files, it has many possible applications within accounting systems. Typical operating speeds of collators range from 240 to 650 cards per minute per hopper. Since both input hoppers may be operated simultaneously, the collator is capable of processing at up to twice these speeds depending on the application.

The Reproducer

This machine, illustrated in Fig. 4.21, performs the function of punching a deck of cards which is a duplicate of an already punched deck. It has two input hoppers, one for the deck to be reproduced and another for unpunched cards which are to become the duplicate deck, and two output pockets. This function can be performed at speeds of up to 100 cards per minute. In performing this and its other functions, the reproducer is controlled by wired control panels. Also included in the repertoire of the reproducer are gang punching, summary punching, and mark sensing.

In *gang punching* part or all of the information on one card is punched into all subsequent cards in the deck. A common application of gang punching involves the preparation of a set of transaction cards in which a part of the data, such as the date or a code indicating transaction type, is identical for all cards. This data can be gang punched onto all transaction cards, which reduces the effort required in keypunching and verification.

In *summary punching* the reproducer is connected by a cable with a tabulator, and is used to punch a summary card which contains totals of data items which have been accumulated by the tabulator. This procedure is commonly used in accounting operations involving the updating of files, such as an accounts receivable, accounts payable, or inventory file. The tabulator accumulates the updated balance of the account or item and prints a report, while the reproducer punches an updated file card containing the new balance.

In *mark sensing* the reproducer reads special pencil marks made in specified areas on the face of punched cards and punches the data corresponding to the marks into the cards. Since it enables the capture of source data in machine-readable form at its point of origin, mark sensing is a form of source data automation. Mark sensing is often used in applications in which constant data is prepunched into cards and variable data is entered by marking with a pencil. An accounting example involves the collection of labor cost data, in which the department number, employee number, pay rate, and date may be prepunched while the job and operation number, start and stop time, and quantity completed is marked by the employee.

The Interpreter

This machine, illustrated in Fig. 4.22, performs the function of printing the information which is already punched on a card onto the surface of the card. One

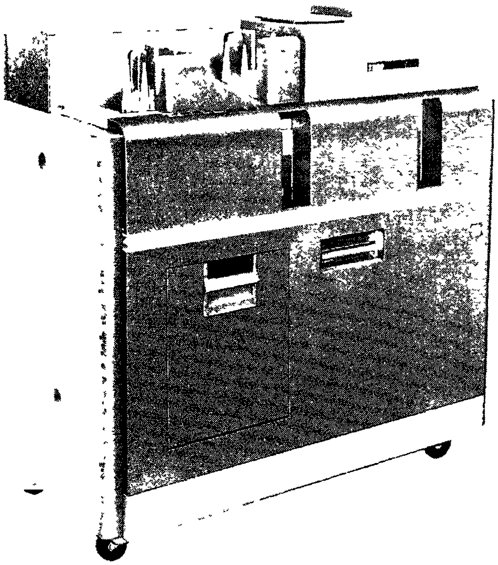


Fig. 4.21 Punched card reproducer. (Courtesy of International Business Machines Corporation.)

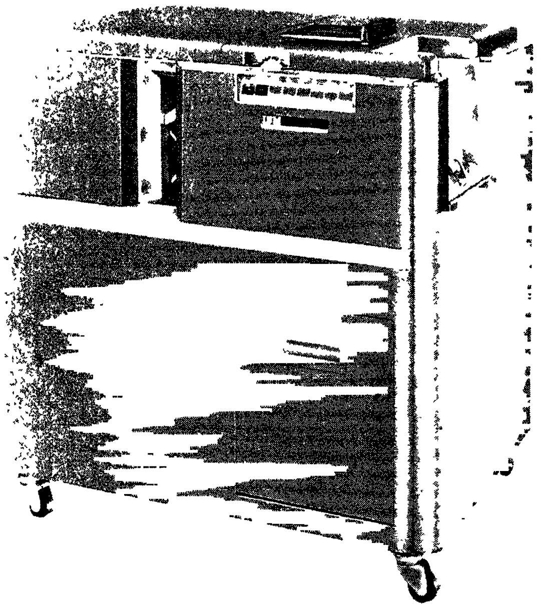


Fig. 4.22 Punched card interpreter. (Courtesy of International Business Machines Corporation.)

common example of the need for performance of this function arises after cards have been punched by the reproducer, which does no printing. Under the control of a wired control panel, the interpreter can print data on any of several lines from the top to the bottom of the card. A common application in accounting is the printing of punched card checks. The speed of operation of the interpreter is typically around 100 cards per minute.

The Calculating Punch

Whereas the tabulator can only add and subtract, the punched card calculator, or calculating punch, can perform all four primary arithmetic operations. This machine can do one or more calculations on data items on input cards, and punch the result on the same card or on the following card. The calculating punch typically has one input hopper and one output hopper. An example is illustrated in Fig. 4.23. The speed of operation of this machine varies with the complexity of the calculation, but an average speed might be from 50 to 100 cards per minute. Its operation is also controlled by means of control panels. Common accounting applications are to multiply rate by hours in computing payrolls, or to multiply quantity by unit cost or unit price in computing total cost or total sales revenue per item.

A General Application of Punched Card Data Processing

As mentioned previously, a configuration of some or all of the punched card machines discussed above can be used as a complete automated data processing system. Many such systems are still in use, but their usage is declining due to competition from small computer systems which provide greater processing speed and reliability at only a slightly higher cost.

In this section an illustration of the use of a punched card system to perform a standard data processing task will be presented. All of the eight punched card machines described in this chapter except for the calculating punch are involved in the illustration. The task, which is perhaps the single most common processing task performed in an accounting information system, is that of periodically updating a master file for the occurrence of transactions, which is referred to as *file maintenance*. In file maintenance the master file always contains some form of current balance for each item in the file, and may contain other information as well. The transactions (which are more generally referred to as *file activity*, or simply *activity,*) are usually in the form of additions to and subtractions from the balance, although the activity may also initiate some other adjustments to the master file. Examples of file maintenance in accounting include the updating of an accounts receivable file for sales and cash receipts, the updating of an inventory file for receipts and issues, and the updating of an accounts payable file for purchases and cash payments. The illustration describes a file maintenance in general terms, but the specific application could be to any of the above or similar operations.

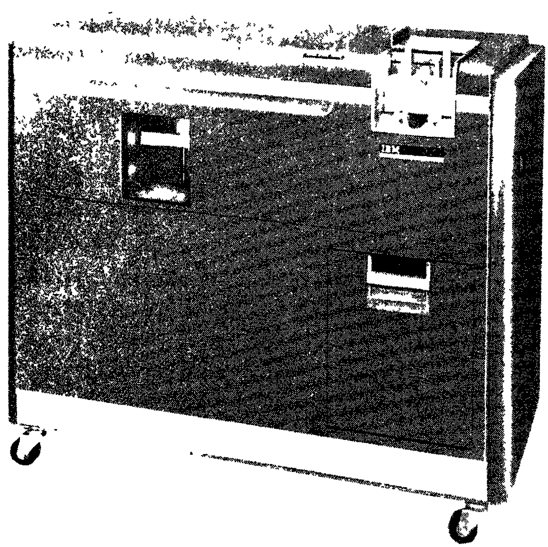


Fig. 4.23 Punched card calculator. (Courtesy of International Business Machines Corporation.)

Assume that the master file is maintained in sequential order on punched cards, with each card representing a different item, such as a customer account or part number. The first operation required in this file maintenance is the preparation of activity cards from source documents using the keypunch and verifier. At a minimum, each activity card must contain an identifying number to enable it to be matched with its corresponding master file card, a code indicating the type of transaction (addition to or subtraction from the balance) and the amount. After these cards are prepared, the sorter is used to arrange them in the same numerical sequence as the master file.

The next step in the process utilizes the collator to match and merge the master file deck and the activity deck. The merged deck produced by this operation contains all master file cards for which there is activity, and each master file card in the deck is followed by all activity cards which correspond to it. All master file cards for which there is no activity are selected out and placed in an output pocket separate from the merged deck. There may also be some activity cards for which there is no corresponding master card, although this is an error condition which requires a separate investigation and correction. If such cards are present, they will be placed in a third output pocket of the collator.

The next step is to process the merged deck of master file and activity cards on the tabulator, which will be wired to read and store the balance from each master file card, to increment or reduce that balance for each of the following activity cards and, after processing the last activity card for each item, to initiate a signal to the reproducer to summary punch a new updated master

file card. The tabulator may also be accumulating other totals which it will print out after all cards are processed, and/or it may be printing a report on the activity.

In the next step the deck of newly punched master file cards is removed from the reproducer and processed on the interpreter, which prints the punched data at the top of the cards. Then the collator is used to merge this deck with the unprocessed master file cards which were selected out in the earlier collator operation. The merging produces a complete and updated master file deck. This deck may perhaps be processed on the tabulator to produce a listing of the updated file, after which it is placed in its regular storage location.

A final step in the process involves the disposition of the merged deck of old master file and activity cards. After being processed on the tabulator as described above, this deck is group sorted on the sorter to separate the old master file cards from the activity cards, and perhaps also to separate the activity cards into different categories. The old master file cards can be thrown away, although they may be saved for a time as a safeguard against destruction of the regular master file. The activity cards may be similarly disposed of, or if the unit record concept is being applied, they may be subsequently used as input to one or more other processing runs. For example, sales activity cards could be used to update an accounts receivable master file, a finished goods inventory master file, and a sales analysis master file.

REVIEW QUESTIONS

1. Define the following terms:

source data automation	gang punching
microcomputer	summary punching
point-of-sale recorder	mark sensing
unit record concept	file maintenance
turnaround document	file activity

2. Describe generally the data processing functions performed by adding machines and calculators, and then give some specific examples.
3. For what types of problems are programmable calculators most useful? Give some examples.
4. Describe the data processing functions performed by the cash register.
5. Give several examples of how the cash register contributes to control of cash sales in a retail business.
6. Describe the various functions which may be performed by point-of-sale recorders.

7. Describe the bookkeeping or posting machine and the functions it performs.
8. Give a detailed example of how the bookkeeping machine might be used in performing a data processing task.
9. Describe some check procedures that can be used with the bookkeeping machine.
10. Briefly describe how some adding machines, cash registers, and bookkeeping machines produce input to computer systems.
11. What is a magnetic stripe ledger record and how is it used?
12. Describe and explain the functions of (a) the portable data recorder, (b) the embossed-card imprinter, and (c) the automatic typewriter.
13. Describe and explain the functions of the primary items of equipment in a microfilm system.
14. Identify and describe the four primary forms of microfilm storage.
15. Explain the advantages and disadvantages of microfilm systems.
16. What are some common applications of microfilm systems?
17. When were the first punched card machines invented, and to what task were they first applied?
18. Explain the unit record concept as it relates to punched card data processing, and describe the advantages offered by this concept in practice relative to less advanced data processing facilities.
19. What facts indicate that the punched card is continuing to thrive as a basic input medium to computer systems?
20. Explain the advantages of turnaround documents and give an example of their usage.
21. Describe the essential features of and the functions performed by the following machines:

card punch	collator
card verifier	reproducer
sorter	calculating punch
tabulator	interpreter

22. How can the extra cost and time required for punched card verification be justified?
23. Why is data preparation usually such a significant portion of the total operating costs of an automated data processing system?
24. Describe several methods of improving efficiency and reducing costs in data preparation.
25. Describe the buffered keypunch and explain its advantages.

26. Describe an example of how the following might be used in accounting work:

group sorting	mark sensing
selecting (with sorter or collator)	the calculating punch
summary punching	the interpreter
gang punching	unit record concept

27. Give a step-by-step description in general terms of the process of file maintenance in a punched card data processing system.

DISCUSSION QUESTIONS

28. In many modern information systems, processing and output functions are automated while input functions are performed manually. Discuss the potential of source data automation. What do you feel are its primary advantages and/or disadvantages?
29. It is stated in Chapter 1 that machines are generally faster and more reliable than people, but also less flexible and adaptable. Of the machines discussed in this chapter are there any exceptions to these general statements? If so, explain.

PROBLEMS AND CASES

30. Construct a table in which all of the functions in the data processing cycle are listed across the top and each machine described in this chapter is listed along the left side. Draw lines in the table to obtain a matrix in which each function is a column and each machine is a row. Within each cell of the matrix, mark an "X" if the machine in that row performs the function in that column; otherwise leave the cell blank.
31. Moose Mursatz operates a small clothing store in Moscow, Idaho. He employs three sales clerks and utilizes a cash register for recording sales. Due to his other business and personal interests Moose is only present at the clothing store during 50% of its hours of business.

    You may assume that Moose's cash register has any or all of the optional features described in this chapter. What procedures would you recommend to Moose to take maximum advantage of the control features of the cash register?
32. You are to design a cash receipts processing system for a bookkeeping machine. Four documents are involved— a cash receipts journal, an accounts receivable ledger card for each customer, a customer statement for each customer, and a deposit slip. All receipts are by check and each must be recorded on all four of the above listed documents. Most customers take a two percent discount offered for early payment.

Required:

a) What data should each document contain?
b) How should the data on each document be arranged, and how should the various documents be aligned relative to each other, in order to enable simultaneous writing on all documents in a single line?
c) What data would the clerk enter; what data would the machine enter?
d) Describe an internal check procedure which could be used to check the accuracy of posting of a batch of cash receipts.

33. The Cain Company uses punched card equipment in its billing operation. As part of this operation, a file of 13,000 prepunched cards is maintained, each of which contains the account number, name, and address of one of the company's 13,000 customers. This file is maintained in sequence by customer account number, a six-digit field. Also maintained are batches of commodity cards, each of which is prepunched with the item number, description, and price of an inventory item.

When a sale is made to a customer, clerks obtain manually a commodity card for each item type purchased by the customer. The customer account number and quantity sold are keypunched onto each commodity card. The billing date is then gang punched onto each commodity card. These commodity cards are then processed with the name and address cards to prepare printed invoices and a summary invoice card. Each invoice contains: (1) the customer's account number, name and address; (2) the billing date; (3) a separate line for each item sold, which includes item number, description, quantity sold, price, and total amount of sale (quantity times price); and (4) the invoice total, or sum of the total amounts for all items sold. Each summary invoice card contains only items (1), (2), and (4) from the above list.

At the completion of this process the summary invoice cards are interpreted and then merged into a permanent file of summary invoice cards, the average size of which is 13,000 cards. The customer name and address file is reassembled for the next day's processing. The commodity cards are saved for use in subsequent processing.

On the average, 1,000 sales orders are processed daily. For each sales order there is an average of 3.9 different item types ordered. Punched card machines used in processing (other than the keypunch and verifier) and their speeds in cards per minute are as follows:

sorter	–650	reproducer	–100
collator	–650 (each input hopper)[2]	interpreter	–100
tabulator	–100	calculating punch	–150

[2]To compute the time required for the collator to perform a matching or merging operation, assume that the collator reads one-half of the cards from the smaller of the two input decks simultaneously with the reading of cards from the larger input deck. The other one-half of the cards from the smaller deck are read while the other hopper is idle.

Required:

a) Describe step by step the sequence of processing procedures necessary to complete the operations described above. At each step indicate the machine used and the total time consumed by that step. Assume that each step requires a set-up time of five minutes. Do not include the keypunching or key verification steps.
b) What is the total required processing time for the entire operation, excluding keypunching and key verification?
c) What are the "subsequent processing" steps for which the commodity cards are saved after the processing operation?

34. The Sunnydale Electronics Company has established a Central Purchasing Office which will be responsible for purchasing of and payment for materials and supplies for all of its divisions. The Central Purchasing Office will use a punched card data processing system.

One of the functions to be automated is the maintenance of accounts payable records and the disbursement of cash in payment of accounts. Input to this process consists of vendor invoices which have been approved for payment. Each invoice contains, among other things, the vendor's name and address, the quantity and price of each item purchased, the gross invoice total, the due date of payment, and the discount rate. In addition to approval of payment, the purchasing department also writes the vendor's code number on the invoice.

The data processing section will maintain a master file in which the data for each unpaid vendor invoice is on a punched card. This file will be sequenced by vendor code number, and augmented each day by the new invoices received that day. Before the invoices are added to the file, the net amount due for each new invoice will be calculated and punched into the card and a printed listing of these new invoices will be prepared.

Each day the cards for which payment is due are to be selected from this file and processed on the tabulator to produce printed checks and remittance advices in one operation. In addition, a printed report listing all cash disbursements for the day is to be prepared.

In performing this processing, the data processing unit has available for use the following machines having the speeds indicated:

keypunch-verifier—	6,000 keystrokes per hour
sorter—	650 cards per minute
collator—	240 cards per minute (each input hopper)[3]
tabulator—	120 cards per minute
calculator—	150 cards per minute
reproducer—	100 cards per minute
interpreter—	100 cards per minute

[3]To compute collator processing speed, refer to footnote 2 to Problem 33.

The data processing section will receive and process an average of 2,000 vendor invoices daily and the average size of the accounts payable master file at any one time will be 20,000 cards.

Required:

a) Design the format of an 80-column card to be used as an accounts payable record. Assume that 50 spaces must be reserved for vendor name and address, that vendor codes are five digits long, that the gross invoice amount will never exceed $9,000.00, that discounts are either 1% or 2%, and that due date is a six-digit field. Also assume that the invoice cards are to be keypunched in batches of 50 and that each batch will be assigned a two digit batch number which will be keypunched into each invoice card.

b) Which fields in the above card should be key verified? How many man-hours will be consumed daily in keypunching and verifying these cards?

c) Prepare a step-by-step description of how the daily processing is accomplished using the punched card system once the cards are keypunched and verified. Indicate which machine is used at each step and how much time the step consumes. Assuming five minutes of set-up time for each step, how much time in total will this processing take?

35. Callison Manufacturing Company wishes to estimate the cost of data preparation for its production information system. This cost includes: (a) rent of keypunch and verifier machines; (b) salaries of keypunch and verifier operators; and (c) cost of punched cards. Given the information below, calculate the total monthly cost of data preparation for the system.

- Monthly keypunching volume – 4,500,000 characters.
- Monthly rent of each keypunch – $80.
- Monthly rent of each verifier – $80.
- 40% of all characters keypunched are keyverified.
- Rate of operation of keypunch and verifier – 6,000 keystrokes per hour.
- Productive hours per month of keypunch and verifier operators – 150.
- Monthly salary of keypunch and verifier operators – $400.
- Number of characters punched on each card – 45.
- Cost per thousand cards – $2.40

Chapter 5

Computer Data Processing Systems

A *computer* is a high-speed electronic device capable of performing arithmetic and logical operations and of storing and executing a set of instructions which will enable it to perform a series of such operations without human intervention. Impetus for the early historical development of high-speed computing machines was provided by the Second World War. In the late 1940's and early 1950's several such machines were developed and used in scientific applications at various government and university sites around the country. Computers were first made commercially available in the early 1950's, and their application to high-volume data processing tasks on a large scale dates from that point.

A major development in computer technology occured in the late 1950's when transistors and printed circuitry replaced the vacuum tubes upon which early computers had been based. This led to computers which were much smaller in size, but also much faster and more reliable. This development was considered so significant that from this point the early computers were referred to as "first generation," and the new ones as "second generation."

In 1963 and 1964, computers with microelectronic circuitry, much smaller and faster than anything before, were introduced. These computers provided a greatly improved capability for handling data communication from remote locations and for executing several different jobs at the same time. So significant were these improvements that a "third generation" of computers was hailed. Though many further advances in computer technology have occurred since 1964, none have been as momentous as the introduction of the third generation of computers. Therefore, many experts feel that the computer industry has not yet truly entered the "fourth generation," even though a new wave of advanced model computers was introduced in 1970 and 1971.

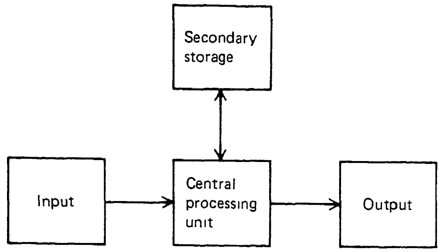


Fig. 5.1 Basic elements of a computer system.

ELEMENTS OF A COMPUTER SYSTEM

The essential elements of a computer system can be divided into two basic categories, *hardware* and *software*. Computer hardware comprises all of the physical equipment necessary for computer processing. Software includes all of the nonhardware elements of a computer system, including programs, programming languages, and documentation. This chapter provides a review of computer hardware and its utilization in business and accounting systems. Chapter 6 provides a review of computer software and programming.

The hardware in any computer system consists of four basic component categories. These are: input devices, central processing unit, output devices, and secondary storage devices. These elements of a computer system and their relationships are diagramed in Fig. 5.1. Figure 5.2 illustrates a modern computer system which includes devices in each of these categories. In this section, each of these four component categories is examined.

Central Processing Unit

The central processing unit, or CPU, is the actual "computer" element of a computer system. The CPU performs three distinct functions: (1) primary storage, (2) arithmetic and logical operations, and (3) control. Primary storage contrasts with secondary storage in that the former holds programs and data for an application while it is being executed, whereas the latter holds programs and data while they are not in use. When a given program or data record is needed by the central processing unit, it is read into primary storage from secondary storage. Any calculations or logical comparisons which are performed on the data in primary storage are executed by the arithmetic and logic unit. The control unit of the CPU interprets program instructions, monitors the flow of data through the CPU, and controls the order of execution of program instructions.

The operator of a computer system controls its functioning by means of the control console of the CPU. In the system illustrated in Fig. 5.2, the console consists of a panel containing various lights and switches and a keyboard and printer. The console panel enables the operator to monitor certain

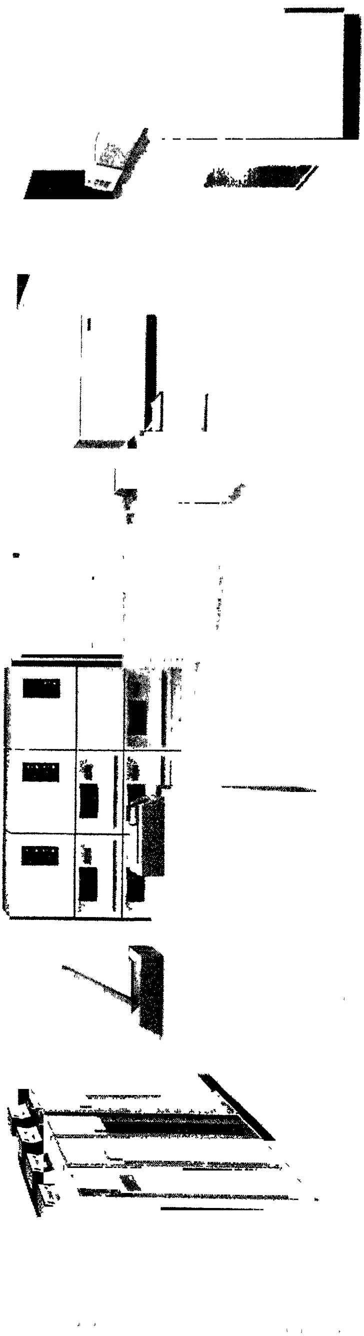


Fig. 5.2 A computer system. (Courtesy of International Business Machines Corporation.)

aspects of the operation of the CPU, while the console keyboard and printer provide limited input-output capability.

The two most common forms of primary storage are magnetic cores and semiconductors. A magnetic core is a very tiny doughnut shaped ferrite ring which can be magnetized or demagnetized by electric current conducted through wires which run through the center of each core. A semiconductor consists of a tiny chip of silicon with miniature circuits inscribed upon it. These two forms of primary storage are contrasted in Fig. 5.3, which shows a closeup of a semiconductor memory chip against a magnetic core plane background.

Magnetic cores were the predominant form of primary storage in computers throughout the 1960's and early 1970's. Integrated circuitry, of which the semiconductor memory is an advanced form, was used only in control and arithmetic and logic units until 1971. Semiconductor memory is smaller and faster than magnetic core memory, but until the early 1970's these advantages did not outweigh its additional costs. Since the first computers with semiconductor memories were installed in 1971, this form of primary memory has become increasingly significant and will probably be dominant by the late 1970's.

The basic unit of data in a computer system is the *bit* (short for "binary digit"). Each magnetic core or semiconductor circuit represents a single bit of data. The bit can assume one of only two possible states, which might be referred to as "on" and "off," or "1" and "0." For example, a magnetic core may be magnetized in one of two directions (clockwise or counterclockwise). Similarly, a circuit may be either closed (conducting electricity) or open (not conducting). The bit is the basic means of data representation for not only computer CPUs, but for all forms of computer secondary storage as well.

Since the bit is the basic unit of computer data representation, most computer systems use the binary, or base-two number system. In this system each digit in the decimal (base-ten) number system is represented by a combination of four bits in the binary system, as shown in Fig. 5.4. The decimal equivalent of any binary number can be determined by summing the decimal equivalents of the place values of those bits having a value of 1. The decimal equivalent value of each place in a binary number is equal to 2^n, where n is the place number. For example, a 1 in the sixth place of a binary number has a place value of 2^6 or 64. Place number is determined by counting places from right to left in increments of 1, with the rightmost place having a place number of 0. To determine the decimal equivalent of the binary number 1010101, first determine the place values of place numbers 0, 2, 4, and 6, which are $2^0 = 1$, $2^2 = 4$, $2^4 = 16$, and $2^6 = 64$, respectively. Then sum the resulting place values (1+4+16+64) to give the result of 85.

To the accountant, an exposure to the concepts underlying the internal functioning of computers is useful from the standpoint of developing a general understanding of computer data processing. In view of his responsibility for auditing and control functions, the accountant should also be aware of some of

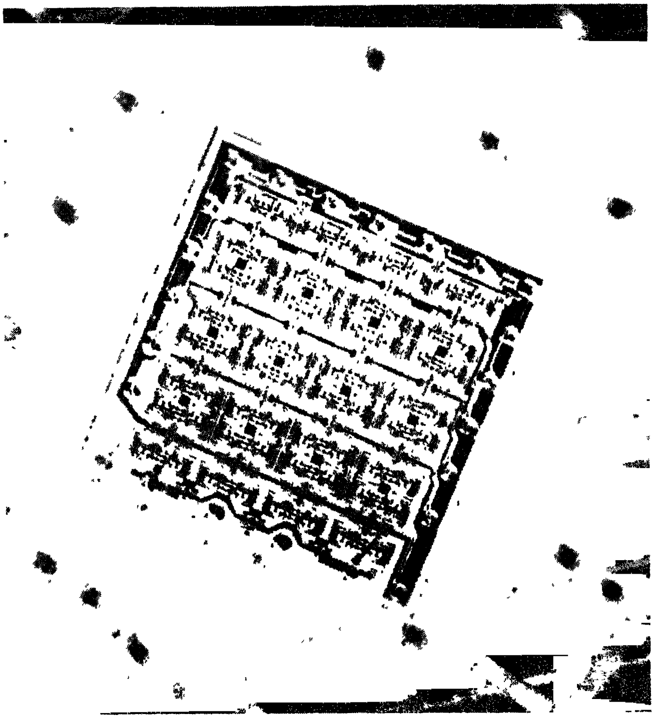


Fig. 5.3 Semiconductor memory chip with magnetic core plane in background. (Courte of International Business Machines Corporation.)

decimal number	binary equivalent			
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
place number	3	2	1	0
place value	8	4	2	1

Fig. 5.4 Binary equivalents of decimal digits.

the cost and performance factors in CPU selection. A few of the important measures of CPU performance include access time, execution time of addition, multiplication and division instructions, and data transfer rate. Access time refers to the time required to retrieve data from memory. Access time for data in core memory averages around 1 to 2 *microseconds* (millionths of a second) in modern computers. Semiconductor memories offer faster access times of from 10 to 400 *nanoseconds* (billionths of a second). Execution times in modern computers vary widely, from less than one to several hundred microseconds. Transfer rate refers to the speed of movement of data from one area in primary memory to another, and ranges from 100,000 to several million characters per second in modern computers. In general, increases in primary memory size and CPU performance correspond to increases in cost. Some further considerations in the selection of CPU features are discussed in a later section of this chapter.

Input Devices and Data Media

The subject of computer input encompasses three major elements, which are: the media upon which data are recorded for entry to computer systems; the devices for original recording of data on the input media; and the devices for reading data from the input media into the central processor. Six basic forms of input discussed in this section are: (1) punched cards, (2) magnetic tape, (3) punched paper tape, (4) magnetic ink character recognition (MICR), (5) optical character recognition (OCR), and (6) online data entry by terminal.

Punched cards. Punched cards have been the primary medium for preparation of source data for computers since the earliest application of computers in business. The punched card and its preparation are discussed in Chapter 4. The most common type of punched card is the 80-column card, illustrated in Fig. 4.16. A type of punched card which is becoming increasingly popular in small computer systems is the 96-column card, illustrated in Fig. 5.5. The standard 96-column card is about one-third the size of the 80-column card, which gives the former an advantage of smaller storage space requirements.

The punched card reader is the device which reads punched card input into the computer. This machine senses the pattern of holes in each card, converts the pattern into electronic impulses, and transmits these impulses via a cable to the central processor. The speed with which punched card reading can be performed by available card readers ranges from 300 to 1,200 cards per minute, which is slow relative to other forms of computer input. Fig. 5.6 illustrates a card reader which doubles as an automatic card punch output unit.

Magnetic tape. Data are represented on magnetic tape by means of magnetic bits rather than holes. The magnetization of a bit is analogous to the presence of a hole in a punched card. A reel of magnetic tape is typically one-half inch in width and up to 2,400 feet long. Magnetic tape generally has seven or nine horizontal rows, called tracks, into which data are recorded. Fig. 5.7 illustrates the standard character pattern of seven track magnetic tape.

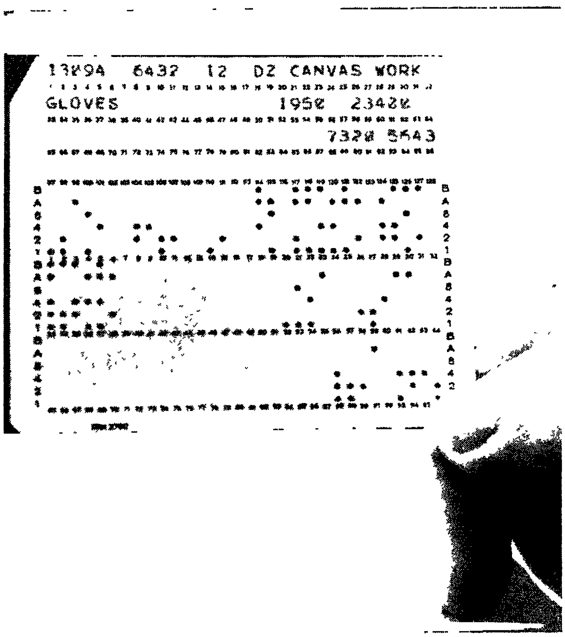


Fig. 5.5 96-column punched card. (Courtesy of International Business Machines Corporation.)

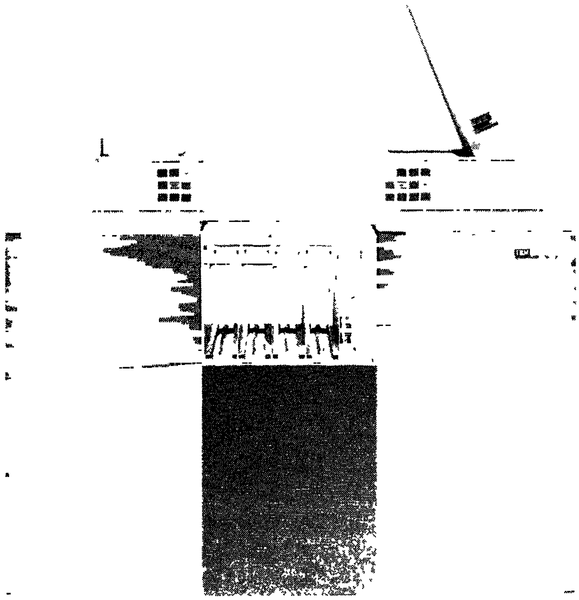


Fig. 5.6 Card reader and card punch unit. (Courtesy of International Business Machines Corporation.)

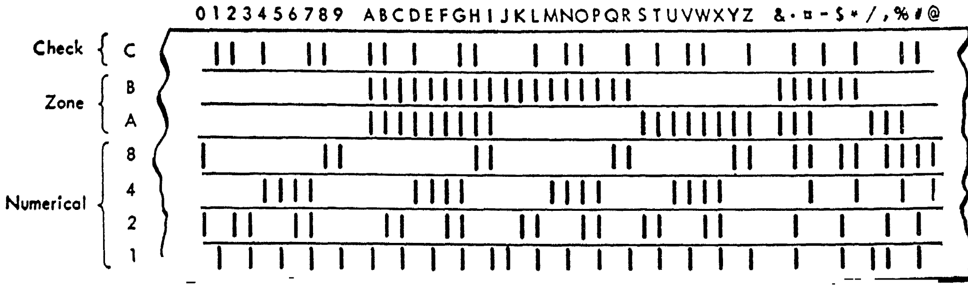


Fig. 5.7 Standard character pattern for seven track magnetic tape. (Courtesy of International Business Machines Corporation.)

The illustration shows that each character in the character set is represented by some combination of magnetization of the seven bits in a single column. A set of bits such as this which forms a single character of information is called a *byte*. Among the seven bits in each byte are: four numeric bits, which are used to record numeric digits in binary form; two zone bits, which are used in most non-numeric characters; and a check bit. The check bit, called the *parity bit*, is a redundant bit which is not part of the character itself but is used in checking the accuracy of each byte. The parity bit will be magnetized only if the number of the other six bits that is magnetized is an odd number; in this way the total number of bits in any column should always be even. If a bit is lost, the check would be violated and the erroneous data would be discovered. (The system described is an *even parity* system. It is also possible to have *odd parity,* where every column contains an odd number of magnetized bits.)

The concepts of the byte and of parity checking are not unique to magnetic tape, but are used in internal computer processing and in most forms of storage as well. While the seven bit byte has been common for many years on magnetic tape and other storage media, the nine bit byte is growing in popularity. A major reason for this is that two numeric characters, each using four bits, can be recorded in a single nine bit byte, with the ninth bit used for parity checking. This means of compressing data to require less total storage space is called *packing*.

The original recording of source data on magnetic tape may be done in one of several ways. One means of direct recording of data on magnetic tape is the keyboard-to-tape encoder, illustrated in Fig. 5.8. This device is similar to the keypunch, with the data being recorded on tape instead of punched cards. Data may also be recorded on tape by a shared processor key-to-tape system or by a key-to-disk-to-tape system. In a shared processor key-to-tape system, several keyboard stations are connected to a small computer which in turn is connected to several tape recording devices. A key-to-disk-to-tape system is also a shared-processor system, but one in which the memory of the small computer is augmented by a disk memory unit to increase the capacity of the system.

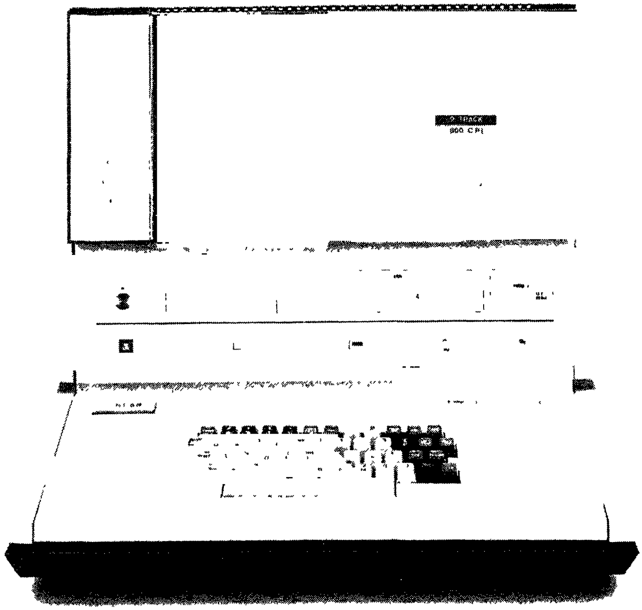


Fig. 5.8 Keyboard-to-tape encoder. (Courtesy, Singer Business Machines.)

Source data may also be recorded on magnetic tape after first being recorded on punched cards, either by a special device for this purpose called a converter, or by a small peripheral computer in a large system having more than one computer.

Data on magnetic tape is read into the central processing unit by means of magnetic tape drive units, an example of which is illustrated in Fig. 5.9. A tape drive also is used to write data from the central processor onto magnetic tape. Typical peak operating speeds of available tape drive units range from 30,000 to 180,000 characters per second. Magnetic tape is by far the fastest of the commonly used forms of input as well as output.

Punched paper tape. This medium is generally prepared as the by-product of the operation of other devices, several examples of which were discussed in Chapter 4. Punched paper tape contains five or eight rows, called channels, across its width, into each of which may be punched a small round hole. The standard character pattern for eight channel paper tape is illustrated in Fig. 5.10. Paper tape readers operate in a manner analogous to punched card readers in sensing the pattern of hole punches and converting the corresponding data into electronic impulses which can be interpreted by the central processor. In appearance a paper tape reader is somewhat similar to a magnetic tape drive. Average speeds of available paper tape readers range from 250 to 1,000 characters per second.

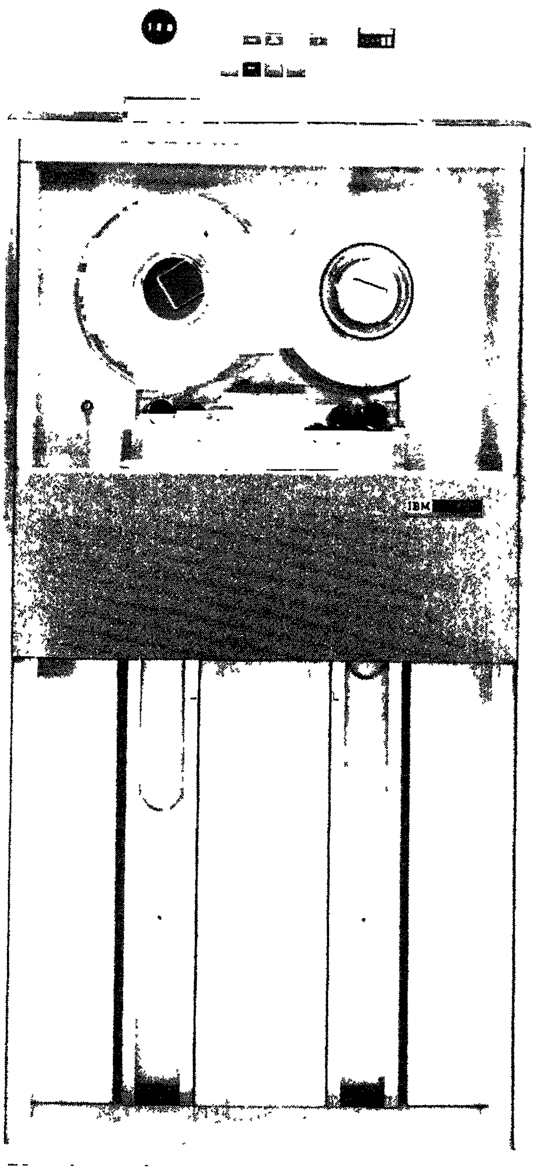


Fig. 5.9 Magnetic tape drive unit. (Courtesy, International Business Machines Corporation.)

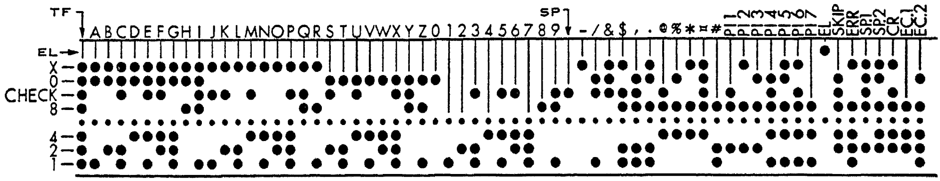
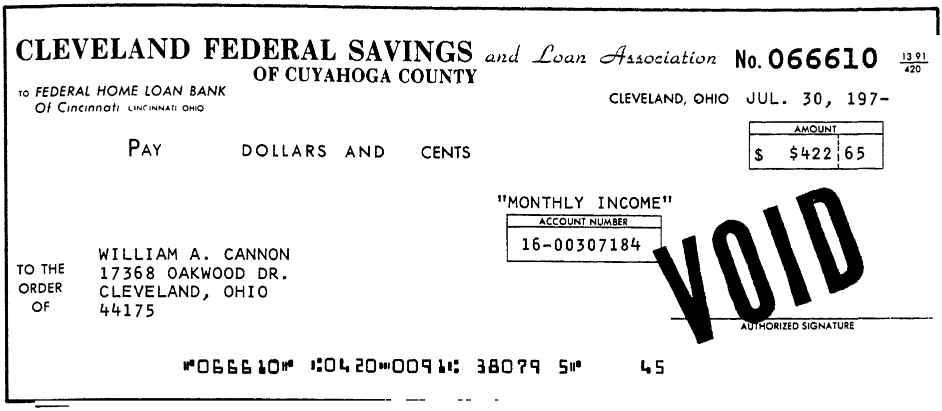


Fig. 5.10 Standard character pattern for eight channel paper tape. (Courtesy of International Business Machines Corporation.)

Magnetic ink character recognition. MICR involves the use of special stylized characters encoded on documents in a special magnetic ink. The most important and familiar application of MICR is in the banking industry for encoding of account numbers and dollar amounts on checks. A sample bank check encoded with magnetic ink characters appears in Fig. 5.11. The original encoding of magnetic ink characters on a document is performed with special inscribers. MICR readers have speeds ranging from 700 to 1,600 characters per second. Many MICR readers also function as MICR document sorters. Fig. 5.12 provides an illustration of an MICR reader-sorter.

Optical character recognition. OCR is a technique for reading documents containing ordinary typing or handwriting into a computer system. OCR differs from MICR in that the former does not require characters printed in a special magnetized ink. However, each model OCR reader can read only a limited number of type fonts. A *font* is a complete character set (digits, letters, and special symbols) in which the size, style, and shape of each character is rigidly specified. OCR is commonly used on turnaround documents, such as oil company statements and bank credit card transaction documents. A sample document printed in a font readable by OCR appears in Fig. 5.13. Reading speeds of typical OCR readers range from 500 to 1,500 characters per second. Fig. 5.14 provides an illustration of an OCR system.

Data terminals. The data terminal does not use any form of physical input medium, but instead enables input data to be entered directly into the computer via an online keyboard. The two major forms of data terminal are the teleprinter, illustrated in Fig. 5.15, and the cathode ray tube, or CRT, terminal, illustrated in Fig. 5.16. Input is originated with these devices by means of a keyboard similar to that of a typewriter. On a teleprinter, input is typed onto a paper copy as it is entered, and output from the computer is also typed onto the paper copy. Many teleprinters, such as the one in Fig. 5.15, also have attached paper tape units, which enable paper tape to be produced as a by-product of terminal operation and/or read into the computer through the terminal. Input and output on a CRT terminal appear on a screen similar to a television screen. With many CRTs a hard copy unit may be attached to the terminal to produce a paper copy of the data on the screen when desired. Data



CLEVELAND FEDERAL SAVINGS *and Loan Association* No. 066610 $\frac{13\text{-}91}{420}$
OF CUYAHOGA COUNTY
TO FEDERAL HOME LOAN BANK
Of Cincinnati CINCINNATI OHIO
CLEVELAND, OHIO JUL. 30, 197-
AMOUNT
$ $422 65
PAY DOLLARS AND CENTS
"MONTHLY INCOME"
ACCOUNT NUMBER
16-00307184
TO THE ORDER OF
WILLIAM A. CANNON
17368 OAKWOOD DR.
CLEVELAND, OHIO
44175
VOID
AUTHORIZED SIGNATURE
066610 0420 0091 38079 5 45

Fig. 5.11 Sample bank check with magnetic ink characters. (Courtesy of The National Cash Register Company.)

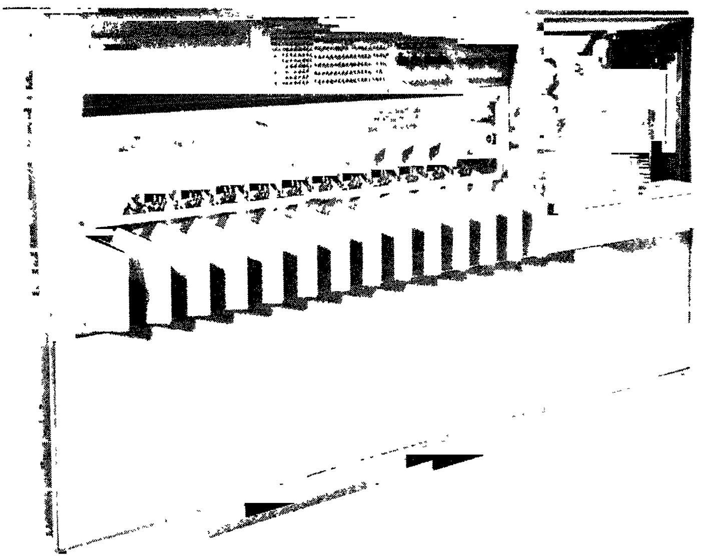
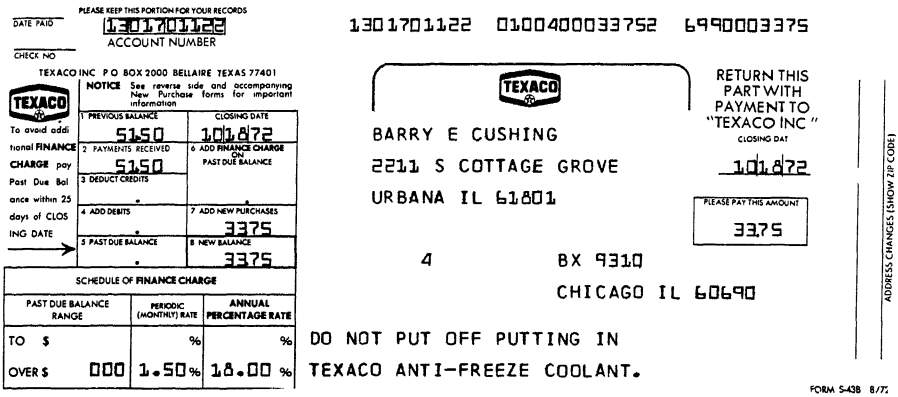


Fig. 5.12 MICR reader-sorter. (Courtesy of International Business Machines Corporation.)



PLEASE KEEP THIS PORTION FOR YOUR RECORDS

DATE PAID

1301701122
ACCOUNT NUMBER

CHECK NO

TEXACO INC P O BOX 2000 BELLAIRE TEXAS 77401

TEXACO

NOTICE See reverse side and accompanying New Purchase forms for important information

To avoid additional FINANCE CHARGE pay Past Due Balance within 25 days of CLOSING DATE

1 PREVIOUS BALANCE 5150	CLOSING DATE 101872
2 PAYMENTS RECEIVED 5150	6 ADD FINANCE CHARGE ON PAST DUE BALANCE
3 DEDUCT CREDITS	
4 ADD DEBITS	7 ADD NEW PURCHASES 3375
5 PAST DUE BALANCE	8 NEW BALANCE 3375

SCHEDULE OF FINANCE CHARGE

PAST DUE BALANCE RANGE		PERIODIC (MONTHLY) RATE	ANNUAL PERCENTAGE RATE
TO	$	%	%
OVER $	000	1.50%	18.00 %

1301701122 0100400033752 6990003375

TEXACO

BARRY E CUSHING
2211 S COTTAGE GROVE
URBANA IL 61801

RETURN THIS PART WITH PAYMENT TO "TEXACO INC"

CLOSING DAT
101872

PLEASE PAY THIS AMOUNT
3375

4 BX 9310
CHICAGO IL 60690

DO NOT PUT OFF PUTTING IN
TEXACO ANTI-FREEZE COOLANT.

ADDRESS CHANGES (SHOW ZIP CODE)

FORM S-43B 8/72

Fig. 5.13 Sample OCR document.

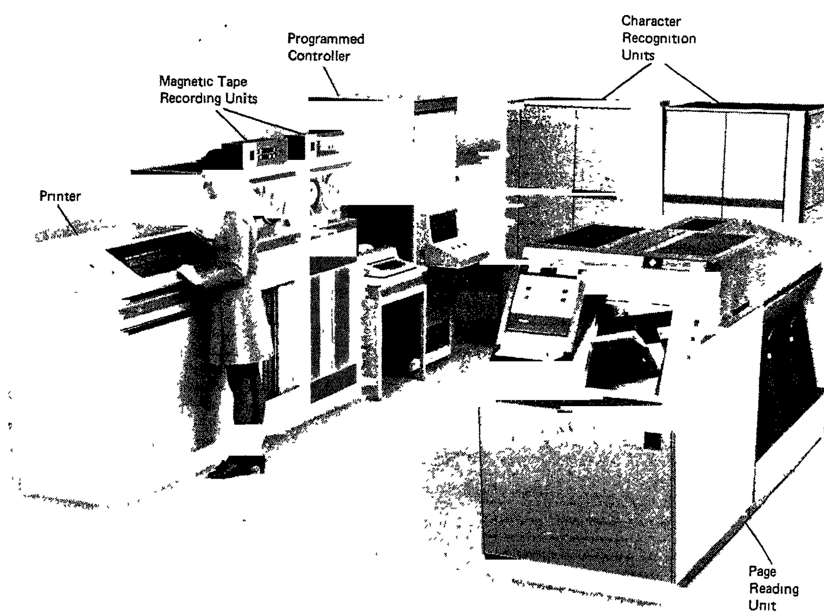


Fig. 5.14 Large-scale optical character recognition system. (Courtesy of Recognition Equipment Incorporated.)

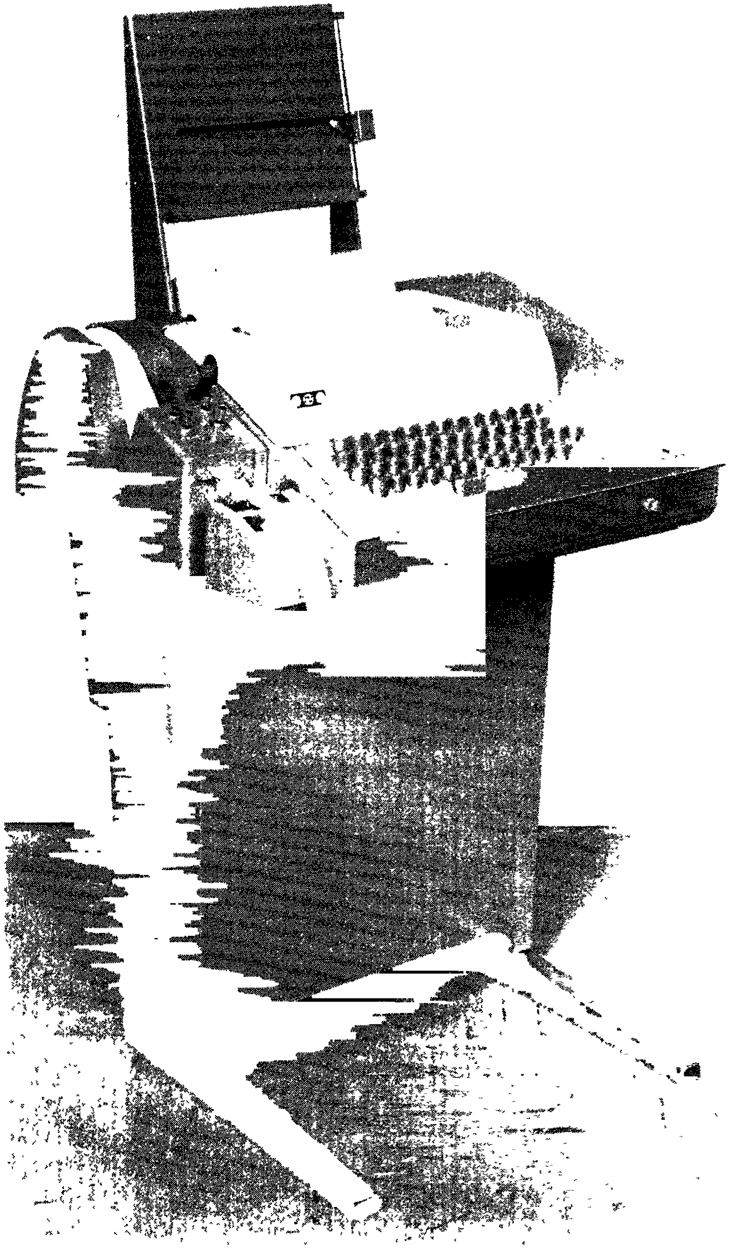


Fig. 5.15 Teleprinter. (Courtesy of Teletype Corporation.)

Fig. 5.16 CRT terminal. (Courtesy of Hazeltine Corporation.)

terminals are commonly used at locations remote from the central processor, with input and output being transmitted by telephone lines or special cables. A third type of data terminal is the push-button telephone, which sometimes incorporates the picture phone screen as a device for displaying input and output.

Input for accounting applications. Accounting applications differ to such an extent that any of these various forms of input may be appropriate for some accounting uses. Some of the characteristics of accounting applications that are relevant in selecting input devices and media in a computer system include: a relatively high volume of input; a need for reliability; and a need for documentation of activity for purposes of reference, control, and audit. Punched card input is most common and most economical in accounting systems; however, it has disadvantages. Card punching is not highly reliable, and while reliability can be increased by means of key verification, this reduces the economic advantages of card input, particularly in small systems. In very large systems the volume of input in accounting applications may make the relative slowness of card input a disadvantage. Though visible documentation is provided by card input, the use of cards as permanent documentation is pro-

hibited in most accounting systems of any size by the large amount of storage space required to store punched cards.

MICR and OCR devices and input media require more expensive input equipment than does the punched card. However, in a large-volume operation this additional expense may well be justified. These forms of input provide economical data preparation in that much of the data on a document may be automatically preprinted. This factor also increases the reliability of data preparation. Both MICR and OCR provide input speeds somewhat faster than punched cards, and both provide visible documentation which requires less storage space than punched cards.

The superior speed of magnetic tape input makes it quite attractive for high-volume applications. The reading of magnetic tape input is quite reliable. Key-to-tape systems provide faster data preparation than keypunching, particularly relative to the unbuffered keypunch. With the single station key-to-tape encoder, the need for reliability demands a separate key verification step; however, with a shared processor key-to-tape system, most if not all of the required data editing and verification may be performed by the shared processor. Magnetic tape does not provide visible documentation; however, it is quite economical as a permanent storage medium because a large volume of data can be stored on a single reel.

Punched paper tape provides the advantage of economical data preparation in machine-readable form at the point of data origin. Punched paper tape is roughly equivalent to punched cards in terms of the speed and reliability of reading. However, the preparation of paper tape as a by-product of other operations is not always reliable as a means of data preparation. Furthermore, paper tape does not provide a visible form of documentation.

Terminal input is most useful for those accounting and other applications in which files must be kept current, and in which input and inquiry to the files originates at many widely separated locations. Terminal operation is often performed by unskilled operators, which makes this form of input slower and potentially less reliable than other forms. Because it is often necessary to have terminals located at many separate locations, the cost of the terminals and related data communication may be relatively high. With respect to documentation, the teleprinter produces a visible record of input data, but CRT terminals do not unless a special auxiliary device is attached.

Output devices

As mentioned in the preceding section, several input devices also double as output devices. These include teleprinters, CRT terminals, and magnetic tape drives. Other computer output devices include: (1) card punches, (2) paper tape punches, (3) printers, (4) audio response units, and (5) computer output microfilm (COM) systems. Of all of these forms of output, the printer is universally used, magnetic tape drives and card punches are very common, and the rest are much less common.

Punched paper tape output is produced by automatic paper tape punches at speeds of from 100 to 200 characters per second. This form of output is less common than many others because of the disadvantages of paper tape as an output and storage medium. Output speeds are slower than those of other media. Paper tape does not contain printing and is therefore not readable by people. Paper tape is also inflexible in that its content cannot be changed and the data recorded on it cannot be separated to perform sorting.

The automatic card punch produces punched card output at speeds ranging from 100 to 500 cards per minute. In some systems the card punch and card reader are a single unit, an example of which is illustrated in Fig. 5.6. This form of output is quite common in accounting systems due to the frequent usage of turnaround documents in such systems. Automatic punching of cards which subsequently return to the system as input assures savings and increased reliability in data preparation.

The printer is illustrated in Fig. 5.17. Typical printer speeds range from 200 to 1,500 lines per minute. In addition to printed reports prepared on regular computer printout paper, accounting documents such as invoices, purchase orders, and paychecks can be prepared on the printer by using special preprinted forms. Printers may be operated online to the computer, or offline with a tape-to-print converter.

Two basic categories of printers are impact printers and electrostatic printers. Impact printers, by far the most common, print by striking an embossed character against an inked ribbon positioned next to the paper. This operation is of course similar to that of the typewriter. Electrostatic printers display the image to be printed on a cathode-ray tube and then copy the image using a technique similar to xerography. Electrostatic printers are much faster than impact printers, with operating speeds ranging up to 5,000 lines per minute. However, electrostatic printers are also much more expensive than impact printers, and cannot produce carbon copies, as can impact printers.

Audio response units are used to provide computer response by "voice" to telephone inquiries. They are most useful when the desired response is relatively small in content and when no documentation is necessary. Examples related to accounting include the checking of a customer's credit by a sales clerk and the inquiry to determine the size of a customer's account balance by a bank teller.

Computer output microfilm devices use a photographic process to produce computer output in the form of a roll of microfilm. In addition to providing the advantages of microfilm generally (see Chapter 4), this approach is an extremely fast output technique, with output speeds ranging from 20,000 to 50,000 lines per minute. COM recorders may either be operated online to the computer or offline with input from magnetic tape. Figure 5.18 illustrates an offline COM system, with the recorder at right and tape input unit at left. The primary disadvantage of this form of output is the cost of the COM recorder and other necessary microfilm equipment.

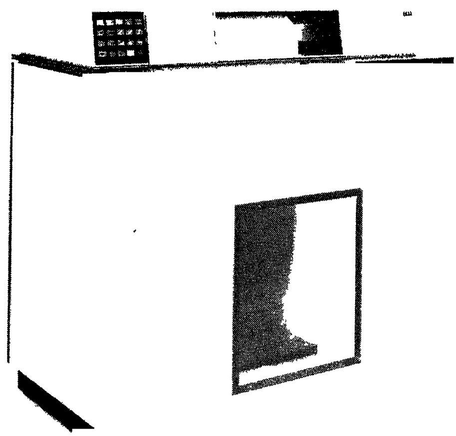


Fig. 5.17 Printer. (Courtesy of International Business Machines Corporation.)

Secondary Storage Devices and Media

Two basic categories of secondary storage are *sequential access* storage and *direct access, or random access,* storage. A sequential access storage medium is one in which any single record stored on the medium may be accessed only after first reading all other records which precede it. All records in a file stored on a sequential access medium must be maintained in sequential order, numerically or alphabetically, according to an identifying number or name which is stored in the same field within each record. The field in which this identifying number or name appears in a record is called the *control field* or *key* for the file of which the record is part. For example, the control field of an accounts receivable file may be the customer account number. The two basic forms of sequential access media are magnetic tape and punched cards. Sequential access files are generally stored offline when they are not being processed.

A random access storage device is one in which any single record stored in the device may be accessed directly without reading any other records. A file stored on a random access device must have a control field, and may have more than one. Such a file may or may not be ordered sequentially according to one of its control fields. The most common form of random access storage device is the magnetic disk. Other random access storage devices include magnetic drum and magnetic strip. Random access files are often maintained online to the computer at all times.

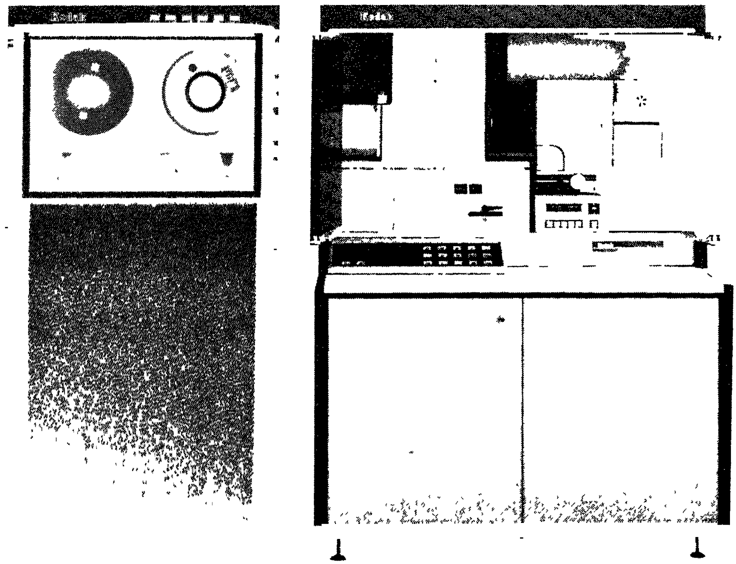


Fig. 5.18 COM recorder with companion tape drive. (Courtesy of Eastman Kodak Company.)

Sequential access storage media. Though the punched card is the most common form of source data input to computer systems, its use as a secondary storage medium is not nearly as common. However, punched cards do have some advantages over magnetic tape as a secondary storage medium. The basic advantage is that the expense of magnetic tape drive units is avoided in a system which does not utilize magnetic tape. Punched cards themselves are in some ways more flexible than magnetic tape as a storage medium. Cards can be read by visual inspection, whereas magnetic tape cannot be. It is thus easier with punched card storage to change or extract for reference purposes a single record or small number of records. Furthermore, a tape reel is not divisible in accordance with the size of a file. Some small files may consume only five to ten percent of the capacity of a tape reel.

Magnetic tape possesses several significant advantages over punched cards as a secondary storage medium. One is its much faster input speed, a factor explained in the earlier discussion of input media. A second is that magnetic tape requires a significantly smaller storage area for the same quantity of data. Data may be very tightly packed on magnetic tape, with 800 bytes per inch being a

typical recording density. A typical reel of tape might hold as many as 20 million characters. At 80 characters per card, 250,000 punched cards would be required to hold the same amount of data.

A further advantage of magnetic tape over punched cards as a storage medium is that magnetic tape records may be of variable lengths without causing problems. However, if a punched card record is smaller than the capacity of the card, the unused spaces are wasted; whereas if the record is larger than the capacity of the card, a single card is not sufficient to hold the record. Another advantage is that the data recorded on magnetic tape may be written over with new data, so that each reel of tape may be reused many times.

Direct access storage devices. Data are recorded on magnetic disks, drums, and strip units using the same general principle as magnetic tape. Each contains bits which may be magnetized or nonmagnetized, and a byte is represented by a group of seven or nine bits, including one parity bit.

A magnetic disk storage unit is a device which contains a set of magnetic disks and a mechanism for reading and writing data on the disks. In some disk storage units, the set of disks, called a disk pack, is removable from the storage unit, whereas with others it is not removable. A set of magnetic disks has the appearance of a stack of phonograph records. There is space between each plate, and information is recorded on both the upper and lower surfaces of each plate. Typically there is one read-write head for each surface. Data is accessed by the head moving over the surface while the disk is revolving. A magnetic disk drive unit with a removable disk pack is illustrated in Fig. 5.19.

Disk storage units vary widely in size and other features. A typical storage capacity for a small disk unit, such as the one in Fig. 5.19, is 7.25 million bytes. Such a unit might rent for around $500 per month, or $.00007 per byte per month. The average time required to access a record stored in such a unit ranges from 30 to 75 milliseconds, depending on the unit. (A *millisecond* is one-thousandth of a second.) A typical large capacity disk unit, such as the one illustrated in Fig. 5.20, might have a capacity of 100 million bytes and rent for around $7,000 per month. The device illustrated provides an average access time of 30 milliseconds.

In some smaller computer systems which have limited file storage requirements, disk storage has completely replaced magnetic tape as the secondary storage medium. The smaller disk units cost less than a set of magnetic tape drive units, and the direct access feature of disk storage is also a desirable feature. Larger systems commonly utilize both magnetic tape and disk storage, using disk for storage for which the direct access feature is necessary, and tape for all other data.

Some accounting applications are well suited to the utilization of direct access storage devices such as magnetic disk, while others do not require it. A multiproduct firm in a competitive industry finds it very useful to have immediate access to up-to-date information regarding the availability and location of an assortment of products in various price ranges and styles. A large manufacturing

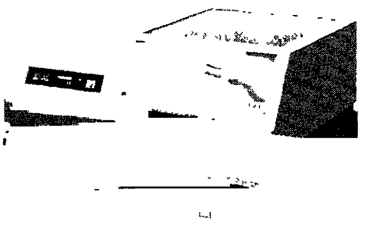


Fig. 5.19 Magnetic disk storage unit. (Courtesy of International Business Machines Corporation.)

company may require immediate access to data on parts inventories. Banks and retail stores often require immediate access to data on customer accounts. Generally most business organizations find sequential access storage acceptable for such accounting applications as payroll and accounts payable.

Magnetic drums and magnetic strips are much less common forms of direct access storage than magnetic disks. A magnetic drum is a metal cylinder, the outer surface of which is used to record information. Read-write heads are stationary and the drum revolves in order to move a given address under a read-write head. The magnetic drum offers a faster access time than magnetic disk, averaging about 10 milliseconds. However, cost factors favor disk over drum storage, and the typical drum unit has a smaller capacity than most disk units. An average sized drum unit contains a 4 million character capacity and rents for $2,000 per month, a cost per character of $ .0005 per month. This is seven to eight times the cost per character of disk storage, and in most applications the faster access time does not justify this extra cost.

Magnetic strip storage devices consist of a group of strips of tape on which data is recorded. These strips hang in a circular box called a data cell. The data cell has a mechanical device which can bring individual strips to the read-write heads and replace them when finished. Magnetic strip file storage generally provides a greater capacity, is slower, and is less expensive than magnetic disk. A typical data cell unit has a capacity of 300 million characters and would rent for about $2,500 per month. This represents a cost per character per month of approximately $ .000008, which is about one-eighth of the cost per character of

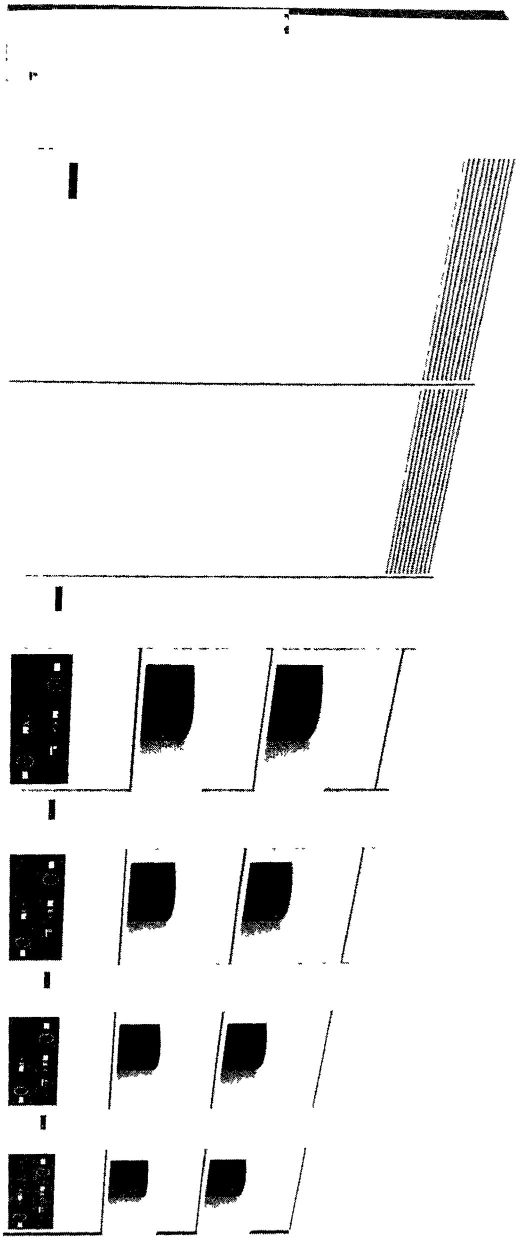


Fig. 5.20 Large-capacity disk storage unit. (Courtesy of International Business Machines Corporation.)

disk storage. However, the average access time of a record in a data cell is 500 milliseconds. This is too slow for a system which has a high volume of file inquiries and updating. In addition many small- and medium-sized business systems do not require the tremendous file storage capacity which magnetic strip storage provides. The primary utilization of magnetic strip storage is for very large files which are infrequently subject to inquiry and updating. A magnetic strip storage unit is illustrated in Fig. 5.21.

COMPUTER DATA PROCESSING IN BUSINESS AND ACCOUNTING

Computer applications are generally divided into two basic and distinct categories: (1) business data processing, and (2) scientific applications. The use of a computer system for business data processing typically involves a high volume of input and output, and computations which are routine and simple. Business data processing is typified by such accounting applications as updating an accounts receivable master file for sales and cash receipts transactions, or processing employee time cards to update a payroll master file and print paychecks.

In sharp contrast to business data processing, scientific applications often involve limited input and output, but require a great deal of computation. Of course computers may be used in the application of a scientific technique such as statistical analysis or operations research to a business problem, but such an application would still be categorized as scientific rather than as a business data processing application. Though the computer system in a business organization may be used for some scientific applications, the vast majority of its volume of work is likely to be for business data processing applications.

The two possible modes of business data processing are batch processing and online processing. In this section these two modes of processing are described and contrasted. Various considerations relating to computer system efficiency are discussed and the technique of systems flowcharting is described and illustrated.

Batch Processing

Many data processing applications in business and accounting consist of the updating of master files for the occurrence of transactions or other activity. In the previous chapter this process is referred to by the term file maintenance. Due to the high volume of input which is typical of many business data processing applications, it is common in business systems for transactions to be accumulated in batches which are processed at given time intervals or after the batch reaches a certain size. This method of data processing is referred to as *batch processing*.

The first step in a typical batch processing application in a computer system is the conversion of input data from source documents to machine-readable media such as cards or tape. For example, in a cash disbursements application in an accounting information system, data could be punched onto cards from vouchers which have been approved for payment. Alternatively the data could be directly keyed onto tape using a key-to-tape or key-to-disk-to-tape device.

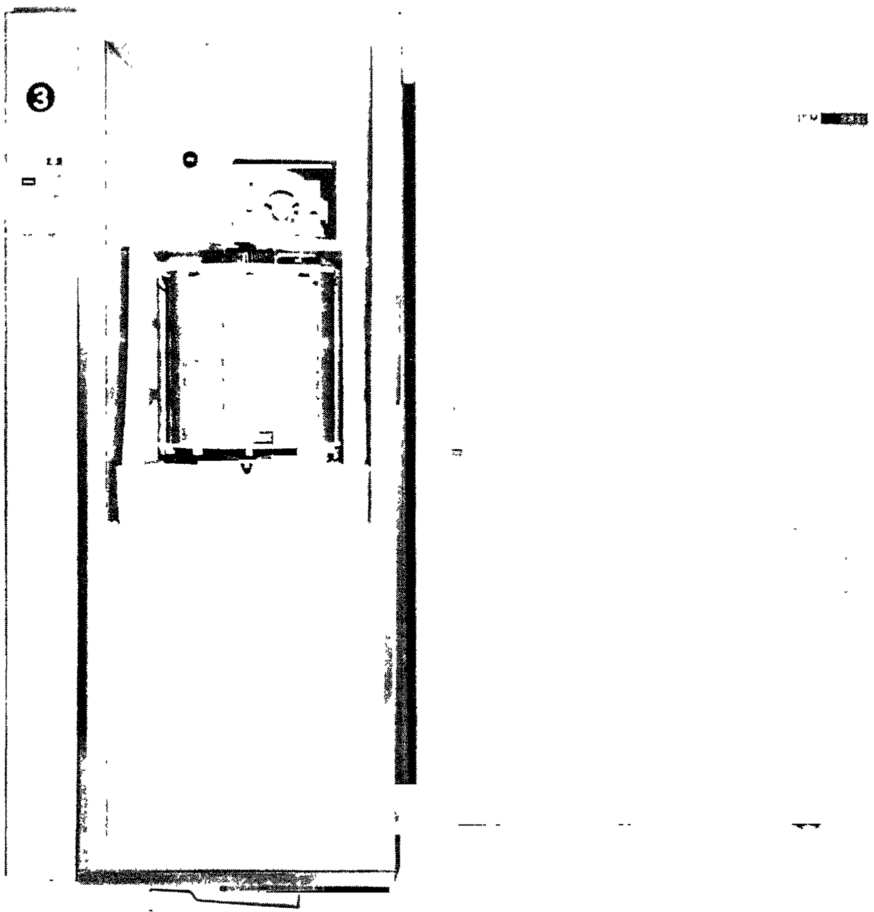


Fig. 5.21 Magnetic strip storage unit. (Courtesy of International Business Machines Corporation.

If the transactions are to be processed sequentially, the next step is to sort the transactions into sequential order. Continuing the above example, assume that the accounts payable master file is stored sequentially by vendor number. The cash disbursements transaction data would then also have to be sorted into sequential order by vendor number. If these data had been punched onto cards, the sort operation could be done offline by a punched card sorter. Alternatively, the unsorted cards could be read to transfer their contents to tape or disk. If this is done, or if the data were originally keyed directly onto tape, they would then be sorted by a routine controlled by the central processor.

An alternative means of assembling transactions for batch processing is called *remote batch processing*. This approach involves accumulating transaction data for batch processing at one or more locations which are geographically separated from the central computer. The data may be accumulated on cards, magnetic tape, or paper tape. When a batch of transactions is ready to be processed, it is read into a special terminal and transmitted to the central computer by telephone lines or special cables.[1] At the central computer site, the data may be written onto tape or disk and then sorted in preparation for processing.

Once the transactions have been sorted, the next step in batch processing is to process them on the computer together with the master file. The master file itself is most likely stored on either magnetic tape or disk. The central processor executes a file maintenance program, which results in the reading of the transactions and master file records and the writing of an updated master file, as well as perhaps other documents and reports. Continuing the cash disbursements example, this processing would result in the printing of checks in payment of accounts due, the printing of a summary report listing erroneous transaction data, batch totals, and a summary journal entry, and the writing of a new accounts payable file updated for the vouchers and the checks issued.

Either a sequential access or direct access storage medium can be used for a file which is updated by batch processing. If the file medium is sequential access, such as punched cards or magnetic tape, batch processing is the only practical means of file updating. Even if the file storage medium is an online device such as magnetic disk, batch processing is still a common form of file updating. However, the direct access feature of online storage makes it possible to consider methods of processing more advanced than batch processing.

Online Processing

The term *online processing* refers to the processing of individual transactions through a system as they occur and from their point of origin as opposed to accumulating them in batches. Online processing generally requires that data files be maintained on a direct access storage device. Two major categories of online processing are *online updating* and *inquiry processing*. In online updating individual transactions are processed to update a file immediately as they occur. In inquiry processing the computer system responds to inquiries from users about information in the file. In online processing the means of input is generally a network of data terminals, many of which may be geographically remote from the location of the central computer system.

In online updating the keying of a transaction into the system initiates the direct accessing of the record in storage to which that transaction pertains. That record is read into the central processor, updated, and then written back onto the online storage device. At the same time a record of the transaction itself may be written on tape or some other medium. The process may also result

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[1]The subject of data communications is discussed in Chapter 7.

in the printing of a document relating to the transaction, such as an invoice if the transaction is a sale.

At this point it might be useful to explain briefly how the direct accessing of a record on an online storage device is accomplished. Most files stored on magnetic disk are organized by means of an *indexed-sequential* technique. This means that the records themselves are stored sequentially according to a key, but the file also contains an index which indicates the disk address of each record. This index performs a function similar to a telephone directory or the index of a book. When a particular record is needed, the index is consulted to determine its address. The record is then read directly from that address. The reading of all prior records, which is necessary with files on a sequential access medium, is avoided.

In inquiry processing the nature of an inquiry may be very simple or very complex. The simplest form of inquiry is a request to examine the contents of a particular record in a file. Examples of more complex inquiries would be a request to list all customers whose accounts are more than sixty days past due, or to list the five salesmen in the state of Texas whose total dollar volume of sales was highest for the month of May. To process such inquiries, special programs and advanced file organization techniques are required.

Online updating of files provides the advantage that all records are up to date at all times. Any user can therefore obtain up-to-date information in response to a request. Such a capability is very useful in decision making or in dealing with customers. In contrast, with batch processing, files are only up to date immediately after the processing of a batch is completed, which may be once a day, once a week, or even once a month.

However, online processing has significant disadvantages relative to batch processing. An obvious one is cost. Online processing requires additional hardware, such as direct access file storage and data terminals, as well as additional software, such as inquiry processing programs. Online processing is also less efficient than batch processing in terms of machine utilization — that is it takes more machine time to process a set of transactions individually than sequentially in a batch.

The decision of whether online or batch processing is appropriate for a particular application must be made on an individual basis. Among accounting applications, those best suited to online processing relate to the information necessary to provide high levels of service to customers. For example, if data pertaining to finished goods inventories are maintained by online processing, a salesman utilizing a data terminal can provide up-to-date information to a customer regarding the availability of any number of inventory items. If the customer decides to purchase, the salesman can enter the necessary transaction data on the terminal, resulting in the reduction of inventory balances for the items purchased and the preparation of documents authorizing shipment. The customer can be told on the spot the day upon which he can expect delivery. If batch processing were used for an application of this sort, a salesman would not always be certain whether particular items were available, there could easily

be a delay in delivery due to the time required to process the transaction, and the salesman would be less reliable in estimating a delivery date. Thus an on-line processing system oriented toward customer service can provide a company with a competitive advantage. The crucial question is whether the benefit from such a competitive advantage is great enough to offset the extra cost of the system.

Systems Design Considerations for Business Data Processing

Computer systems for business data processing face a unique design problem. Recall that business systems are characterized by high volumes of input and output and relatively simple computation. However, the speeds of available input and output devices are much less than central processor speeds. Recall also that central processor operating speeds are measured in microseconds or nanoseconds, while the operating speeds of input and output devices are stated in terms of such measures as cards per minute or lines per minute. This creates a basic mismatch of CPU speeds and input-output speeds, which is more severe in business systems because of their high volume of input and output. Business systems are often referred to as *input-output bound* because the speed of completion of business data processing applications is limited by the speed of input and output devices. In contrast, scientific applications are much better suited to currently available hardware because they typically involve limited input and output and a great deal of computation.

Throughput is a word used to indicate the total amount of useful work performed by a computer system during a given period of time. This concept encompasses input and output as well as computation. Approaches to increasing throughput in business systems must focus upon circumventing the basic mismatch of CPU speeds and input-output speeds. Several approaches to this problem are discussed here.

One capability which greatly increases the throughput of modern computer systems is that of *overlap*. This is the capability of the computer system to perform one or more input-output operations and CPU processing simultaneously. Actually a CPU can only execute one instruction at a time. In pre-third-generation computers, after the CPU executed an input or output instruction, it would remain idle until the input or output device completed the task. However, in a third-generation computer system the CPU does not execute input-output instructions. Instead, input and output functions are performed by *channels*, which are the communication interfaces between the CPU and all input-output devices. The CPU can instruct a channel to perform an input or output task, and while the channel is carrying out this instruction, the CPU may continue processing. CPU processing is thus carried out simultaneously with input and output operations.

The number of input and output operations which may be overlapped with CPU processing is a function of the number of channels in the system. A channel is like a tiny computer which specializes strictly in input and out-

put functions. Once a channel has completed its assigned input or output function, it signals the CPU that the input data has been read into the electronic memory of the channel or that the output data has been written. The CPU may then instruct the channel to perform another input or output function. The overlap capability does not eliminate the basic mismatch of CPU speeds and input-output speeds, but it at least assures that the CPU does not remain idle while waiting for input and output operations to be performed.

Third-generation computers also permit *multiprogramming,* which is the simulataneous execution of two or more programs on the same computer system. Recall that the CPU cannot execute more than one instruction at one time, and therefore can only work on one program at a time. However, modern CPUs are so fast that they can switch back and forth among a number of different programs fast enough to keep the input and output devices for all of the programs working at peak speed. Though the CPU is only working on one program at any one instant, the computer system as a whole is executing several programs at the same time. For example, one program might be reading a deck of cards and transferring their contents to tape while simultaneously a second program is reading a second tape and writing its contents on a printer and a third program is handling terminal inquiries relating to a disk file. Needless to say, this capability greatly increases the throughput potential of a computer system.

While overlap and multiprogramming are capabilities that come with the system itself, several avenues to increased throughput are available to the systems designer. One example relevant to accounting information systems is the application of the principle of exception reporting. This principle indicates that the output reports from a system should only include that information which might affect a user's decision or cause him to take action. Complete listings of all data in a file are not necessary if only a fraction of the information is to be used. For example, a report concerning credit customers should perhaps include data on only those customers whose accounts are past due, rather than contain data on all customers. This approach could not only improve throughput in an information system, but increase the usefulness of system output as well.

Other approaches to increasing throughput in business data processing systems involve the use of magnetic tape. Magnetic tape is by far the fastest of all input and output media. Therefore, if tape can be substituted for other media, throughput may be increased. To study tape processing speed and compare it with the speed of other input-output media, it is necessary to understand something of how data is stored on tape.

Records are generally stored on magnetic tape in *blocks* of several records with a gap called the *interblock gap* between each pair of blocks. Figure 5.22 illustrates a section of magnetic tape in which records are stored in blocks of four. In addition to the rated speed of the tape drive, the speed at which magnetic tape can be processed depends upon several factors including: the

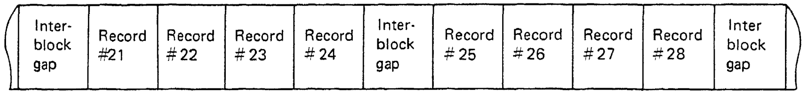


Fig. 5.22 Blocking of records.

size of each record, the number of records in a block, the tape density, and the length of the interblock gap. For example, suppose a file is being processed which has 12,000 records of 150 characters each blocked in sets of four on a tape which has a density of 800 characters per inch with a interblock gap of .6 inches. Suppose further that the rated speed of the tape drive is 60,000 characters per second. The total time required to process the file will include both the time required to read the records themselves and the time required to pass the interblock gaps. To determine the time required to read the records, first determine the total number of characters in the file (12,000 records × 150 characters per record = 1,800,000 characters) and then divide by the speed of the drive (1,800,000 characters ÷ 60,000 characters per second = 30 seconds). To determine the time required to pass the interblock gaps, first convert the tape speed to inches per second (60,000 characters per second ÷ 800 characters per inch = 75 inches per second). Then divide this figure into the number of inches per interblock gap to determine the time required to pass each interblock gap (.6 inches ÷ 75 inches per second = .008 seconds). Then determine the number of interblock gaps, which is equal to the number of blocks (12,000 records ÷ 4 records per block = 3,000 blocks and 3,000 interblock gaps). Finally, multiply the time to pass each interblock gap by the total number of interblock gaps to determine the total time required to pass the interblock gaps (.008 seconds per interblock gap × 3,000 interblock gaps = 24 seconds). Add to this the time required to read the records to obtain the total file processing time (24 seconds + 30 seconds = 54 seconds).

All of the figures used in the above example are typical of magnetic tape processing, so the time estimate obtained provides a good basis of comparison of tape with other media. Using a high-speed card reader with a speed of 1,200 cards per minute, and assuming that each 150 character record would require two cards, twenty minutes would be required to process the same 12,000 records. This is over twenty times the processing time required for the magnetic tape file. Comparisons with other input-output media favor magnetic tape by equally lopsided margins. Thus if a systems designer can substitute tape for other input-output media in a system, throughput can be significantly improved.

There are several ways in which tape may be substituted for other input-output media. One is by the direct encoding of source data onto tape using a key-to-tape or key-to-disk-to-tape system. Several other methods involve converting source data from cards to tape or from tape to other output media. For example, card-to-tape conversion may be accomplished by an offline

converter which simply reads the data from cards and copies it onto tape. Similarly, an offline tape-to-printer converter may be used. Another approach is to use microfilm output, in which case magnetic tape is both the computer output medium and the COM input medium. In a large installation having several computers, one or more small peripheral computers may be devoted exclusively to card-to-tape and tape-to-print routines, while the main CPU processes only tape. In a system having multiprogramming capability, card-to-tape and tape-to-print utility routines may be processed simultaneously with other jobs.

One other factor which affects throughput in a business data processing system is the size of primary storage in the CPU. Generally, a larger primary storage area provides a greater capability for multiprogramming. Also, the number of records which may be contained in a block of records is limited by the size of the memory area available for holding blocks of records. This factor is significant because the more records there are in a block, the fewer are the number of interblock gaps, which enables faster tape processing speeds. Therefore an increase in CPU memory size could potentially increase throughput in a business data processing system.

Of what relevance are these considerations to the accountant? With his responsibility for auditing management performance and cost control reporting, the accountant should be concerned with the feasibility and efficiency of computer system operations. Furthermore, as discussed in Chapter 2, the controller or other accounting executive in a business organization is often directly responsible for management of the computer function. It is therefore important that the accountant obtain a broad perspective of some of the primary efficiency factors in systems design and management. This section has attempted to provide such a perspective as well as a foundation for further study.

Systems Flowcharting

A *flowchart* is a diagrammatical representation of the flow of information and/or the logical sequence of operations in a process or system. Several different types of flowcharting exist. A *systems flowchart* is a flowchart of the flow of data through a series of operations in an automated data processing system. Many of the topics covered in this chapter may be integrated with a discussion and illustration of systems flowcharting. The flowcharting symbols shown in Fig. 5.23 are used as a basis for such illustration in this chapter and throughout the remainder of the book.

The use of systems flowcharting symbols is best described by means of illustrations. Figure 5.24 illustrates a generalized batch processing system for file maintenance, with punched cards and magnetic tape as the primary media used. The chart could apply to any number of specific applications, such as the updating of an accounts receivable file for sales or cash receipts transactions, or the updating of an inventory file for issues and receipts. This particular flowchart illustrates the use of over half of the symbols in Fig. 5.23.

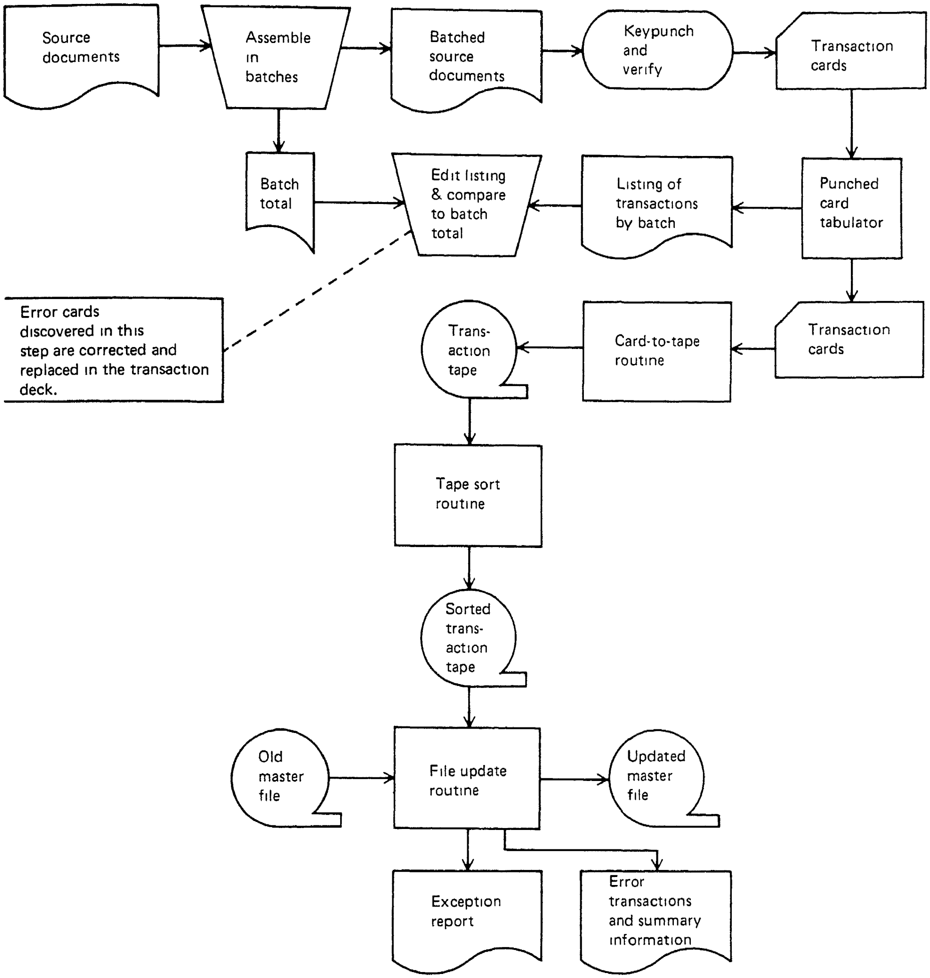


Fig. 5.24 Systems flowchart of a generalized batch processing system for file maintenance.

tape to generate an updated master tape, an exception report, and a report listing error transactions and summary information for the run.

The systems flowchart not only illustrates the flow of data through a system, but is also indicative of the hardware configuration necessary to perform the process. For example, the hardware required for the process in Fig. 5.24 includes a keypunch, verifier, punched card tabulator, card reader, central processor, three tape drives, and two printers. Actually, the tape sort might require four or five tape drives, though it is conventional to show only the unsorted input tape and sorted output tape in a flowchart.

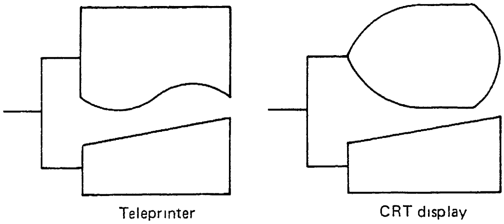


Fig. 5.25 Flowchart representation of data terminals.

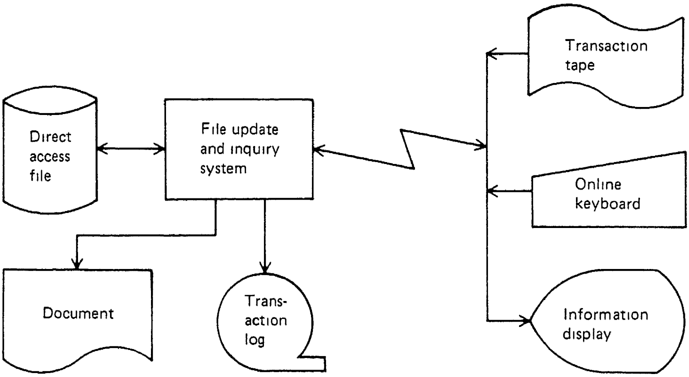


Fig. 5.26 Remote batch and inquiry processing system.

Systems flowcharts of online processing operations generally require the use of some additional symbols. One problem in this regard is that no specific symbol exists with which to represent a data terminal. However, since a teleprinter consists of a keyboard and printer, it can be represented by a combination of the online keyboard and document or report symbols. Similarly, a CRT terminal can be represented by a combination of the online keyboard and information display symbols. These combinations are illustrated in Fig. 5.25.

Fig. 5.26 illustrates some additional data processing concepts as well as the use of additional flowcharting symbols. The system illustrated is a remote batch processing system which also has a capability for remote inquiry processing. Transactions are keyed onto a paper tape as they are originated at the remote site. At periodic intervals the transaction tape is transmitted via the communication link to the central computer facility and processed to update a master file stored on a direct access device. This step also initiates the automatic preparation of a transaction document and the recording of transactions on a magnetic tape file at the central computer installation. This system also provides the capability for initiating inquiries relating to the online file from the online keyboard at the remote site. System responses to inquiries are displayed at the remote site on a CRT terminal or other visual display device.

Systems flowcharts are not only useful for illustrative purposes – they play an important role in the planning, design, and implementation of computer processing applications. They are also an essential factor in the documentation of an information system. These roles of the systems flowchart are discussed in Part Three of this book. In Part Four the systems flowchart plays an important role in the explanation of applications of accounting information systems.

REVIEW QUESTIONS

1. Define the following terms:

   computer
   hardware
   software
   bit
   microsecond
   nanosecond
   byte
   parity bit
   even parity
   odd parity
   packing
   font
   sequential access
   direct access
   random access
   control field
   key
   millisecond
   batch processing
   remote batch processing
   online processing
   online updating
   inquiry processing
   indexed-sequential
   input-output bound
   throughput
   overlap
   channel
   multiprogramming
   block
   interblock gap
   flowchart
   systems flowchart

2. What periods of history correspond to the first, second, and third generation of computers? What major developments in computer technology separate the second from the first generation, and the third from the second?
3. What are the four basic hardware components of a computer system?
4. Describe the three basic functions of the central processing unit of a computer. Explain how the computer operator communicates with a computer system.
5. Describe and compare the two basic types of primary storage.
6. Identify and explain three measures of CPU performance.
7. Describe several basic forms of computer input. In each case, if possible, describe the input medium, the device for recording data on the medium, and the device for reading data from the medium into the computer. Indicate the range of reading speeds of each type of input device.

8. Explain how data are represented on magnetic tape. What advantage does nine track magnetic tape have over seven track magnetic tape for storing numeric data?
9. What are three characteristics of accounting applications which might influence the selection of input devices and media for an accounting system? Use the characteristics as a basis for comparing the various forms of input discussed in Question 7.
10. Identify and describe several forms of computer output devices and media. If possible, indicate for each a range of output speed.
11. Explain the differences, in terms of operation, performance, and economics, between impact printers and electrostatic printers.
12. Identify the two basic categories of secondary storage and explain their essential differences.
13. What are the relative advantages and disadvantages of punched cards and magnetic tape as a secondary storage medium?
14. What are three major types of direct access secondary storage devices? Explain how data are recorded on them and how they operate. Compare them on the basis of access time, storage capacity, and cost.
15. Give some examples of accounting applications for which direct access file storage may be useful.
16. Compare and contrast the typical business data processing application with the typical scientific application. Into which category would the solution of an operations research model of a business problem using a computer fall?
17. Describe using an accounting example the steps in a file maintenance application using batch processing.
18. Is batch processing only used when the file storage medium is sequential access? Explain.
19. In online processing what means of input and what type of file storage are generally used?
20. Explain how a record is directly accessed in a disk file which is organized using an indexed-sequential technique.
21. What are some examples of the kinds of inquiries to which an inquiry processing system must be designed to respond?
22. What are the relative advantages and disadvantages of online processing and batch processing? How does a systems analyst decide which is more appropriate in a given case?
23. What kinds of accounting applications are best suited to online processing? Describe an example.

24. Will the creation of faster central processing units necessarily increase throughput in business data processing? Explain. What recent developments have helped to increase throughput in business data processing?
25. What approaches to systems design can help to maximize throughput in a business data processing system?
26. Explain why a knowledge of computer system efficiency considerations may be relevant to an accountant.
27. Identify the symbols used in systems flowcharting and indicate the meaning of each.
28. Explain why systems flowcharts are useful in the study of information systems and in the practice of systems design.

DISCUSSION QUESTIONS

29. A major computer manufacturer uses the motto, "Machines should work. People should think." in advertising its products. However, isn't a computer a "thinking machine?" Explain what is meant by the motto.
30. Review the steps in the data processing cycle as described in Chapter 1. Which of the steps can be performed better by a computer system than by a person?
31. Volume of processing is an important consideration in the design of a data processing system. Explain how volume of processing would be taken into consideration in selecting the best equipment configuration for a computer system.
32. Computers are highly reliable. Would you expect that a computer system would therefore have little need for accounting controls to check the accuracy of processing and to safeguard assets? Discuss.

PROBLEMS AND CASES

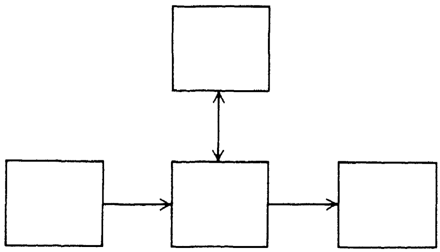
33. Perform the following arithmetic operations:
    a) Convert the binary numbers 110110 and 1101001 to their decimal equivalents.
    b) Convert the decimal numbers 26 and 57 to binary numbers, add the binary numbers, and convert the result back to a decimal number.
    c) Convert the decimal numbers 38 and 21 to binary numbers, find the difference between them in binary, and convert this difference back to a decimal number.
34. You wish to compare the input speeds of several devices. The devices and speeds as given by producers of each device are as follows:

    card reader – 600 cards per minute
    tape drive – 30,000 characters per second
    punched tape reader – 400 characters per second

terminal – 6,000 keystrokes per hour
OCR – 800 characters per second

Your problem is that the device speeds are not all stated in terms of a common measure. Convert all of these speeds to "records per minute" where it is assumed that each input record contains 80 characters. For magnetic tape assume that records are blocked in sets of six and that the time required to pass each interblock gap is 16 milliseconds.

35. The following diagram depicts the four major elements of a computer system and their relationship to one another.



Listed below are several hardware units or components that might be found in a computer system:

a) control unit
b) magnetic drum
c) core storage
d) arithmetic and logical unit
e) cathode ray tube
f) optical character reader
g) printer
h) magnetic tape drive
i) magnetic tape
j) card reader
k) COM recorder
l) paper tape punch
m) magnetic disk
n) card punch
o) semiconductor memory
p) magnetic ink character reader
q) magnetic strip
r) paper tape reader
s) teletypewriter
t) touch-tone telephone
u) audio response unit

Required:

Place the letter corresponding to each of the listed items into the most appropriate box or boxes in the diagram.

36. You are a systems analyst employed by the Acme Manufacturing Company. You have been asked to design a systems application that will control assets and automatically compute each asset's depreciation monthly. It has been determined that a master file will have to be maintained and two output reports produced monthly. It has been further ascertained that the amount of information pertaining to one asset can be represented in 65 characters and that there are approximately 6,000 assets.

a) Given the above information would you recommend the design of a systems application utilizing punched card equipment or a computer system with magnetic tape files? You can assume that there is an adequate supply of both human and machine resources for either approach. Explain the reasons for your recommendation.

b) How would the following changes in assumptions influence your decision? (Consider each assumption separately from the others.)

   i. Management decides that the reports are needed on a weekly basis rather than monthly.

   ii. Due to an unexpected acquisition, the number of assets increased to 60,000.

   iii. The president of the company is demanding immediate action concerning this problem and wants the system to be operational within one week.

   iv. Due to a recent IRS ruling, a new method of depreciation which requires ten times as many arithmetic calculations as the company's present method should be used.

   v. Instead of two reports, it has been determined that 20 reports in different sequences and formats are required.

   vi. Instead of a 65 character master record, 321 characters will be required.

   vii. Management demands that any and all asset records be immediately available for reference on request.

37. You wish to store employee payroll records on a reel of magnetic tape 2,400 feet long with a density of 800 bytes per inch, and with interblock gaps measuring .6 inch. Each record contains 400 characters, and there are 800 byte storage positions available in the central processor for storing a block of input records.

   a) How many employee payroll records may be stored on one reel of magnetic tape?

   b) Assume that the magnetic tape has 9 tracks and that, by storing data in packed form, the equivalent of 80% of the data in each record can be stored at two characters per byte. Compute the effect of this change in assumptions on your answer to part (a).

38. The Dewey Construction Company processes its payroll transactions to update both its payroll master file and work-in-process master file in the same computer run. The payroll master file is maintained on magnetic tape and accessed sequentially, while the work-in-process master is maintained on disk and accessed randomly.

Input to this system is keypunched and verified from job time tickets. The cards are then read into the computer to transfer their contents to magnetic tape. The tape is then processed by a tape sorting routine on the computer to sort the records into sequence by employee number. The sorted tape is then processed to update the files. This run also produces

a payroll register on magnetic tape, employee paychecks and earnings statements, and a printed report listing error transactions and summary information.

Prepare a systems flowchart of the process described above.

39. You are involved in the design of a systems application in which a group of records are to be sorted and processed to update a disk file. The records are originally keypunched onto cards. The hardware which might be used includes a card sorter, a small computer system, and a large computer system. The card sorter operates at 2,000 cards per minute and all costs relating to its operation total $3 per hour. The small computer system has a 1,000-cards-per-minute card reader and tape drives whose operation may be overlapped with the card reader. All costs relating to the operation of the small computer system total $48 per hour. The large computer system also has a 1,000-cards-per-minute card reader, and tape drives which process at 30,000 characters per second. All costs relating to operation of the large system total $120 per hour.

There are 13,500 records of 80 characters each, with a numeric control field of 8 characters. They may be stored on tape in blocks of 9 records. The magnetic tape has a density of 800 bytes per inch and an interblock gap of .6 inch. Assume that every machine operation requires a set-up time of three minutes. Further assume that a tape sort on the small computer would require ten minutes (not including set-up) and on the large computer would require three minutes (not including set-up).

The disk file is part of the large computer system, and its operation may be overlapped with either card or tape input operations. You must determine the fastest and most economical way of sorting and processing the transaction records. Your design choices are (1) sort the cards using the card sorter, after which either (a) the cards could be processed directly on the large computer, or (b) the data on cards could be transferred to tape on the small computer and the tape processed on the large computer; or (2) transfer the unsorted card data to tape on the small computer, after which a tape sort would be performed by either (a) the small computer or (b) the large computer, after which the tape would be processed on the large computer.

Required:

Determine the time required and cost incurred by each of the four approaches outlined above. Assume that the cost rates provided for each machine apply to set-up times as well as operating times. Also assume that processing operations on the large computer are bound by the speed of tape processing.

40. The Golden Valley Utility Company processes its customer billing by computer. Meter reading is done during the first five days of each month, and punched cards, each containing a customer's account number and most

recent meter reading, are keypunched and verified from the meter reading lists. On the sixth day of each month these cards are sorted by a card sorter and processed to prepare customer bills. In addition to these cards, input to the billing run includes (1) an accounts receivable file on magnetic tape, which is sequenced by customer number and contains for each customer the previous meter reading and the due date and amount of any unpaid balance, and (2) a name and address file on magnetic tape, which is sequenced by customer number and contains the name and address of each customer. Output consists of (1) an updated accounts receivable file, (2) a printed report listing errors and summary data, and (3) punched cards upon which are punched all billing data. The latter are then processed on a punched card interpreter to print the billing data on the face of each card, after which they are mailed to customers. Customers are requested to pay their bills prior to the 20th of the month in order to obtain a discount, and are also requested to return the punched card with their payment.

On the 15th, 22nd, and 30th of each month all payments received to date are processed. Payment cards are sorted and processed with the accounts receivable file to prepare an updated accounts receivable file and a printed summary report listing errors such as overpayment or underpayment and summary journal entries. For this run on the 30th of each month a switch is set which causes the printing of a separate report listing all customers who have a payment more than sixty days past due.

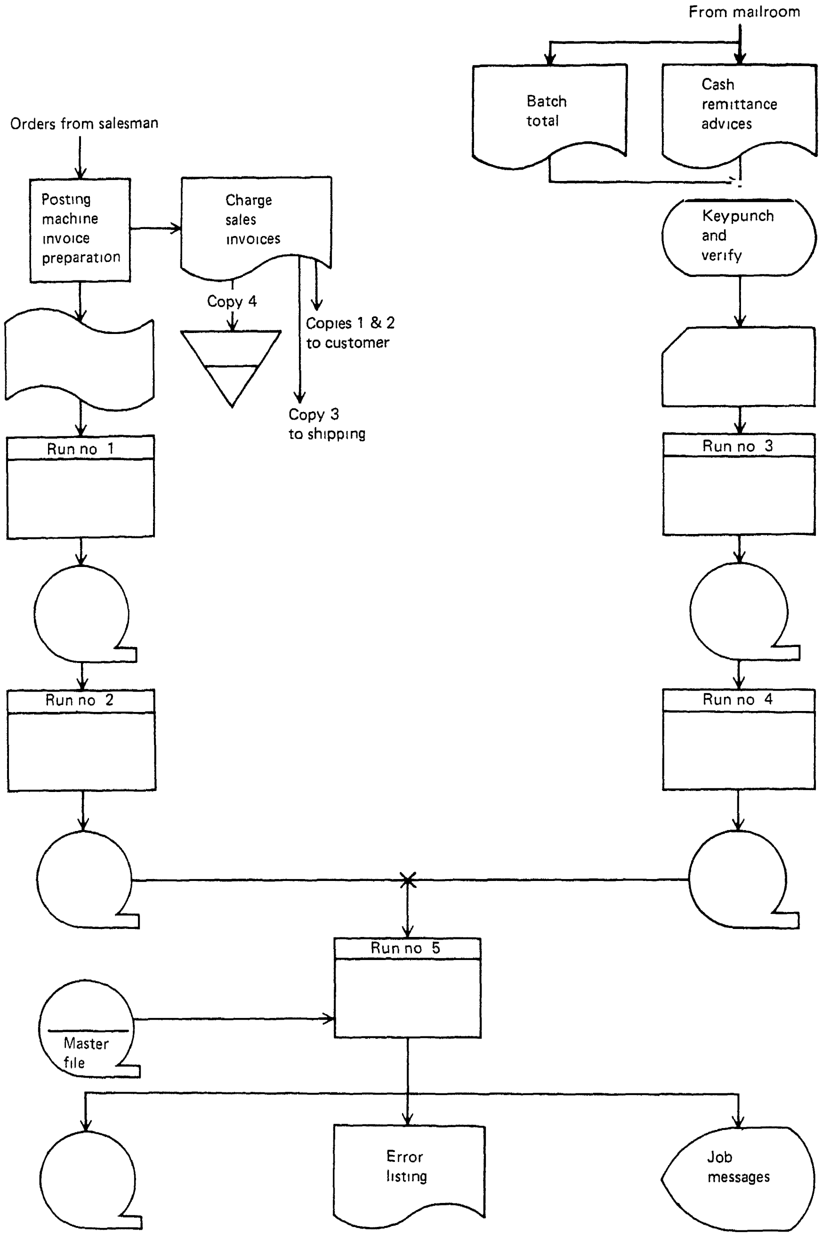
Required:

a) Draw a systems flowchart of (1) the billing run, (2) the cash receipts processing run on the 15th and 22nd, and (3) the cash receipts processing run on the 30th.
b) What hardware configuration is required at a minimum to do all of the processing described in the problem?
c) For what reasons might the customer name and address data be maintained on a separate tape rather than on the accounts receivable tape?

41. The independent auditor must evaluate a client's system of internal control to determine the extent to which various auditing procedures must be employed. A client who uses a computer should provide the CPA with a flowchart of the information processing system so the CPA can evaluate the control features in the system. Shown on p. 148 is a simplified flowchart, such as a client might provide. Unfortunately the client had only partially completed the flowchart when it was requested by you.

Required:

a) Complete the flowchart shown on p. 148.
b) Describe what each item in the flowchart indicates. When complete, your description should provide an explanation of the processing of the

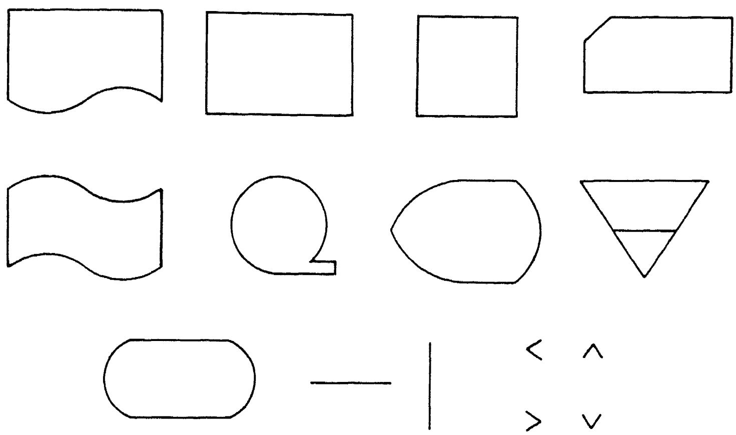


From mailroom
Batch total
Cash remittance advices
Orders from salesman
Posting machine invoice preparation
Charge sales invoices
Keypunch and verify
Copy 4
Copies 1 & 2 to customer
Copy 3 to shipping
Run no 1
Run no 3
Run no 2
Run no 4
Run no 5
Master file
Error listing
Job messages

data involved. Your description should be in the following order:

i. "Orders from Salesmen" to "Run No. 5."
ii. "From Mailroom" to "Run No. 5."
iii. "Run No. 5" through the remainder of the chart.

c) Name each of the flowchart symbols shown below and describe what each represents.[2]



[2]This problem has been adapted from Question 8, Auditing Section, American Institute of Certified Public Accountants Examination, November 1967. Copyright © 1967 by The American Institute of Certified Public Accountants and reprinted with permission. Minor changes have been made in the flowcharting symbols to conform with those presented in this book.

Chapter 6

Computer Software and Programming

The term software refers primarily to computer programs, but also encompasses related nonhardware elements of computer systems. These include operating manuals, program documentation, and the standards and techniques used in systems analysis and program development. Software is certainly as essential a part of a computer system as its hardware. It has been mentioned that one of the features of a computer that sets it apart from less sophisticated data processing devices is its ability to store and execute a program of instructions without human intervention. For a majority of computer users, the costs relating to software, including the personnel costs of systems analysis and programming, exceed those relating to hardware. The purpose of this chapter is to build a foundation of understanding of computer software and its development.

Software development is the objective of *programming,* which might be defined as the process of preparing a set of computer instructions for accomplishing a data processing task or solving a problem. Computer programming has become a significant occupational skill in our society. It is estimated that over 200,000 persons are presently employed as computer programmers. A continuing problem for those organizations which use computers is that the demand for qualified programmers far exceeds the supply.

A SURVEY OF SOFTWARE CONCEPTS

Several major categories of software are reviewed in this section. These include: programming languages, application programs, utility routines, library routines, operating systems, and nonprogram software. The section concludes with a discussion of the software used in accounting systems.

Programming Languages

A programming language is the basic tool that a computer programmer uses to instruct a computer. There are many different programming languages. Each

make of computer has its own *machine language,* in which each of the various instructions which the computer can execute has its own code. Programming in machine language is very difficult, not only because of the complexity and variety of the instruction codes, but also because it requires that the programmer keep track of the address in primary storage of every instruction involved in the program. Because of these difficulties, programming in machine language is no longer common. Most programming in business organizations is done using either of two basic types of programming languages: a *symbolic language* or a *procedure-oriented language.*

In a symbolic language each machine instruction is represented by a mnemonic symbol that bears some relation to the instruction. For example, the instruction to "read a tape record" might be represented by the symbol RT in symbolic language, whereas the same instruction would be a numeric code in machine language. In addition, a symbolic language does not require the programmer to assign and keep track of storage addresses.

Because instructions in its own machine language are the only commands that a computer can directly understand and execute, a symbolic language program must be converted to machine language before it can be used on the computer. This conversion is accomplished by a special program called an *assembler.* In this conversion process, the symbolic language program, called the *source program,* and the assembler are input to the central processing unit, and the machine language program, called the *object program,* is the output. Upon completion of this conversion, the object program is ready to be processed.

In a procedure-oriented language, examples of which are FORTRAN and COBOL, a single instruction can represent a detailed set of machine language instructions. Any instruction which translates into two or more machine language instructions is called a *macroinstruction.* The macroinstructions in a procedure-oriented language may consist of single-formula expressions or even English language words. As a result, they are easier to use and interpret than the codes of symbolic and machine languages.

In contrast to symbolic languages, a procedure-oriented language is *machine independent,* which means that the same language can be used on any make of computer, although some minor differences may exist between different machines. As with symbolic language programs, it is necessary for programs written in a procedure-oriented language to be converted to machine language. Programs which perform this conversion are called *compilers.* The terms source program and object program have the same meaning with respect to compiler programs as they do with respect to assembler programs.

The use of procedure-oriented languages in writing computer programs offers several advantages over the use of symbolic languages. Procedure-oriented languages are generally much easier to learn than symbolic languages. They enable programmers to write programs much faster. Because the language instructions are fairly simple to interpret, a procedure-oriented language pro-

gram offers better documentation than a symbolic language program, which also makes it easier to revise existing programs. The feature of machine independence also provides significant advantages for procedure-oriented languages. Programs do not become obsolete when a new computer is installed. Programs can be shared with other users. General programs for particular applications can be purchased.

There are significant disadvantages of procedure-oriented languages relative to symbolic languages. Perhaps the major disadvantage is that a program written in symbolic language by an expert programmer is likely to be much more efficient than one compiled from a procedure-oriented language. Because there is a one-to-one correspondence between symbolic language instructions and machine language instructions, a programmer writing in symbolic language can take maximum advantage of his expertise in designing an efficient program. It is difficult to design a compiler program that is as skillful as an expert programmer. Thus a machine language program produced by a compiler is likely to be slower and consume more core storage than if the same program were originally written in symbolic language. The difference in computer run time becomes quite significant if the program is one which must be used on a regular basis.

Another disadvantage of procedure-oriented languages is that their regular use may consume significant quantities of computer time in the process of compilation. In contrast, the conversion of symbolic language programs to machine language consumes relatively less time. Still another disadvantage is that a compiler program itself may be quite large, and could require more primary storage than is available on smaller computers.

The question of whether procedure-oriented languages or symbolic languages are "better" for business data processing applications has no clear-cut answer. Some computer users may utilize both, choosing between them on the basis of each individual application. Thus a program to be run only once would probably be written in a procedure-oriented language, whereas a program to be used regularly over a long period of time might be written in symbolic language. Some installations may use only procedure-oriented languages because most of the programmers are not familiar with the symbolic language. Other installations may use only symbolic language because of limited availability of primary storage. Installations which do primarily batch processing may not be making full use of available central processor time, and so would probably be less concerned about the reduced efficiency of procedure-oriented language programs. Generally if there is any trend taking place, it is probably in the direction of greater use of procedure-oriented languages.

Application Programs

Application programs include those which are used for the specific computer applications of the user. A computer user may purchase standard application programs from manufacturers or software vendors, or may prepare his own

application programs. In a business data processing system, many different types of application programs are used. Some of the major categories include: file maintenance, report generation, information retrieval, and problem solving. Each of these application categories is examined in turn in this section.

File maintenance. The most common form of utilization of business data processing programs is for file maintenance, which has previously been defined as the updating of a master file for the occurrence of transactions. Examples of files whose maintenance is an accounting function include payroll files, accounts payable and receivable files, and inventory files. File maintenance may be performed in a batch processing or online processing mode. File maintenance programs also generally perform certain other functions, such as the editing of input data for errors and the preparation of reports and documents.

File maintenance applications generally involve the processing of a wide range of file activity. On the one hand are regularly recurring transactions, such as sale of goods on account or purchase of inventory. On the other hand, there are many different types of nonrecurring transactions, such as the addition or deletion of a record, a change in an employee's pay rate or in the price of an inventory item, or the correction of an erroneous record. Generally it is more efficient to update a master file for all of the different types of transactions which affect it in a single processing run, using a single program. When the number of different kinds of transactions affecting a given file is large, as is commonly the case in many business applications, one can see that the file maintenance program can be very complex.

Report generation. As the name implies, these programs prepare management reports. In business systems, report generation programs generally utilize updated master files as input. The functions which they perform on this data include summarization and highlighting of exception conditions. Examples of summarization by report generation programs include reports analyzing total unit and dollar sales by product line, or reports classifying total accounts receivable into totals of current accounts and past due accounts. The latter can be further classified according to the number of days past due. Examples of highlighting of exception conditions by report generation programs are reports listing the ten best-selling and ten worst-selling products or salesmen, or reports listing all accounts which are more than sixty days past due. Report generation programs may be used in either a batch processing or online processing mode.

Information retrieval. Programs of this type are utilized in online systems to provide quick responses to user inquiries concerning the contents of data files. The functions which they perform include the retrieval and display of any record specified by the user, or the selection and display of records from a file having one or more characteristics specified by the user. An example of the latter function is the selection from an accounts receivable file of all accounts which are both sixty or more days past due and in excess of $1,000. Information retrieval in this sense is synonymous with inquiry processing.

Problem solving. The category of problem-solving applications in business data processing encompasses a wide variety of mathematical analysis techniques used to facilitate management decision making. Of importance are statistical applications involving correlation and regression, analysis of variance, statistical sampling, or time-series analysis. Also significant are applications utilizing operations research models, such as linear programming, inventory models, queueing models, PERT and critical path analysis, and simulation. Other examples include cash flow discounting, forecasting, and cost-volume-profit analysis.

Utility Routines

Programs designed to perform common data processing functions which are a necessary part of many applications are called *utility routines.* Programs to sort and merge files on tape are examples of utility routines. Other examples are programs to transfer data from one medium to another, such as from cards to tape, tape to disk or drum, tape to print, or disk or drum to print. Other examples are debugging aids such as a memory dump program, which prints out the contents of computer memory for analysis, or a trace routine, which results in the printing out of diagnostic information after the execution of each instruction.

Library Routines

Programs written to perform operations which frequently arise as steps in the solution of larger problems are called *library routines.* The most common examples are statistical and mathematical routines such as matrix inversion, square root calculation, random number generation, or determination of natural logarithms. Library routines are generally intended for use as parts or subroutines of larger programs.

Operating Systems

Another important part of the computer software is referred to as the *operating system.* The operating system is a group of programs which control the processing operations of a computer. This system regulates the often simultaneous functioning of all input and output devices. It searches for, and provides, assembler and compiler programs, utility and library routines, and application programs when they are needed. In a broad sense, all assembler and compiler programs, utility routines, application programs, and so forth which are available to be called by the operating system are part of the operating system. Additional functions of the basic operating system include the handling of program interrupts in a multiprogramming system, keeping track of and printing out run time and other statistics relative to each job, supervising the allocation of computer memory space and the retrieval of data and instructions from memory, and communicating with the operator through the console.

Nonprogram Software

An important part of the nonprogram software used in a computer installation are the various services offered by hardware and software vendors. These include maintenance services, training, and assistance in implementation and development of initial application programs. For many years computer manufacturers provided service software of this type, and program software as well, to their hardware customers free of charge. In 1969 International Business Machines (IBM) Corporation, the industry's leading firm, under antitrust pressure from several competitors and from the government, announced an "unbundling," or separation of pricing, for software and hardware. Most other manufacturers in the industry quickly followed IBM's lead. This has tended to stimulate competition in the software field, and has probably resulted in an improvement in the quality of available software products and services.

The various tools and techniques used in systems analysis and programming constitute another category of nonprogram software. Some examples are publications, such as language manuals and trade journals, design checklists, and flowcharting and related design techniques.

A third category of nonprogram software is the documentation of a computer system. For each system application, the documentation should include: a narrative description of the objectives, functions, and cost justification of the application; systems flowcharts; an indication of the equipment configuration used; *record layouts,* which illustrate the arrangement of items of data in input, output, and file records; program flowcharts, and decision tables (as described subsequently in this chapter); program listings; program change descriptions and authorizations; instructions to the operator for running the programs; a list of the recipients of each output report; and a summary of the control feature used in the system. Good system documentation of this type is essential to program development and system control.

Software and Accounting Applications

Many of the early applications of computers in business were to the processing of accounting data. This specialization has been reflected in the development of computer software, particularly in the areas of programming languages and commercially designed application programs. Several programming languages have been created to accommodate the characteristics of data processing applications in accounting, such as high volumes of input and output, and a need for control. Some of the major accounting firms are developing their own higher level languages to assist them in auditing work. Such languages utilize commands which are peculiar to audit work, and programs written using these commands must first be translated into a procedure-oriented language. For example, the command to FOOT must be translated into a procedure-oriented language routine which will accumulate the total of a column of figures.

Many commercially developed application programs are used in accounting operations. Programs for processing payrolls, billing and maintaining customer accounts, keeping inventory records, and so forth are available from manufacturers as well as from firms specializing in software development. For most companies using computers in data processing, there is no need to "reinvent the wheel" by writing such standard programs from scratch when they can be purchased commercially. Even when a company's requirements differ from those assumed in the standard application programs, such programs can often be appropriately modified.

Since more and more accounting work is being performed by computer systems, there is a need for accountants to understand software concepts and functions. This does not mean that accountants should have a detailed knowledge of programming; however some familiarity with at least one programming language does provide a useful perspective. Of greater importance is the need for accountants to understand system documentation as a basis for understanding and controlling computer applications in accounting.

THE LIFE CYCLE OF A DATA PROCESSING PROGRAM

A student obtaining an initial exposure to programming is likely to conceive of a computer program as a device prepared to solve a single problem, after which it is discarded. With regard to programs for business data processing, this is a misconception. A program written for a business data processing application may be used every day for several years. It will be useful to examine the life cycle of a data processing program in two separate stages, preparation and utilization.

Program Preparation

The time required for program preparation may range from a few weeks to over a year, depending upon the complexity of the program. This section describes the several steps in the preparation process.

Preliminary steps. The first step in the preparation of a computer program for business data processing is to gain authorization for the project. This requires a statement of objectives and an analysis of costs and benefits as justification for the program. Output requirements and input sources must be determined, and the contents of files must be specified. A systems flowchart is prepared to illustrate the preliminary design of data flows relative to the program.

Program flowcharts. Once approval of the project has been obtained, the next step is the detailed design of the program. This begins with the drafting of a *program flowchart,* or *block diagram,* which illustrates the sequence of logical operations performed by a computer in executing a program. The program flowchart might be said to represent the detailed steps performed within the central processor symbol of the systems flowchart. Like the systems flowchart,

the program flowchart uses a set of symbols with specialized meanings. These symbols and their meanings are identified in Fig. 6.1. The symbols shown are from the standard flowchart symbols adopted by the American National Standards Institute (ANSI).[1]

The flow direction line is used to connect the other symbols, and indicates the sequence in which logical operations are performed. In the absence of the arrowhead or other directional indicator, the sequence of operations is assumed to proceed from the top and/or from the left of a page to the bottom and/or to the right. The input/output symbol represents either the reading of input or the writing of output. The decision symbol represents a check or comparison of one or more variables and the transfer of flow to one of two or more alternative locations depending upon the results of the comparison. The processing symbol represents a data movement or arithmetic operation, such as the assignment of a value to a variable or the performance of a calculation. All points in a program flowchart at which the flow begins, ends, or is interrupted are represented by the terminal symbol. The entry or exit connector is not a logic symbol, but merely provides a convenient means of representing the continuation of the logic flow at a different location on the chart. Each connector in a flowchart is labeled with a digit or capital letter. When the logic flow reaches an exit connector, it continues from that point at the entry connector having the same label. Whereas several exit connectors may have the same label, there can be only one entry connector with a given label.

A simple illustration of a program flowchart appears in Fig. 6.2. After starting, the program reads a record, which results in a value being assigned to one or more program variables. The next step compares one of the values read to a number which is known to occur on the last record only, such that if the record *is* the last record, the program branches to print a total and stop. If the record is *not* the last record, the next step accumulates a total based upon the data read from the record. The connector following this step indicates that flow control transfers back to the point where another record is read. The program continues through this loop of reading a record and accumulating a total until the last record is recognized.

A more complex example of a program flowchart illustrating a generalized file maintenance program appears in Fig. 6.3. It is assumed that there are two sets of inputs to this program, a master file and an activity file, which are ordered in the same sequence. Each master file record contains an identifying number and a balance, and each activity record contains an identifying number and a positive or negative amount to be entered to its corresponding master record. There may be several activity records pertaining to a single master record, or there may be none for some master records. Output produced by the program consists of an updated master file and a printout of errors and summary data.

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[1] *American National Standard Flowchart Symbols and their Use in Information Processing*, X3.5, American National Standards Institute, 1971.

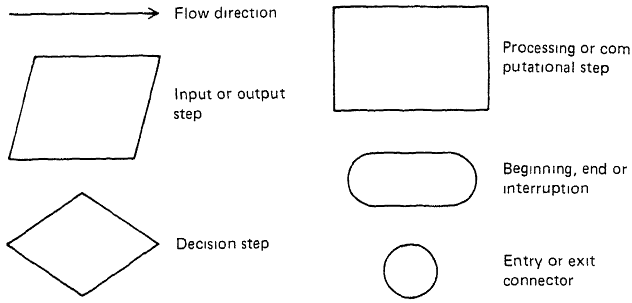


Fig. 6.1 Program flowchart symbols.

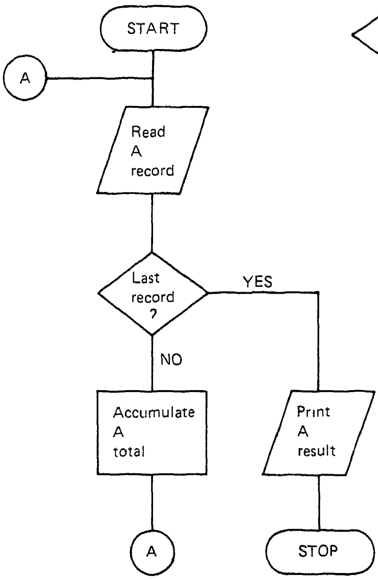


Fig. 6.2 A simple program flowchart.

After reading both a master record and an activity record (Steps 1 and 2), the file maintenance program compares their identifying numbers (Step 4). If these are equal, a match exists and the program posts the activity amount to the master balance (Step 6) and reads another record (Step 2). This loop is continued until an activity record with a higher number is read. At that point program control is shifted by the identifying number comparison to the sequence headed by connector C, which writes the new master record (Step 7). The fact that the identifying number of the activity is greater than the identifying number of the master indicates that there is no more activity pertaining to that master, which is why the new master record is written at this point. The next step is to read the next master record (Step 8) and then compare its identifying number with that of the previously read activity record (Step 4).

If a comparison of identifying numbers reveals that the master number is greater than the activity number, this indicates that the activity record was not matched with a master record. This is an error condition, since a master record should be present for every activity record. If this condition arises, the program prints an appropriate error message identifying the number of the activity record (Step 5) and proceeds to read another activity record (Step 2).

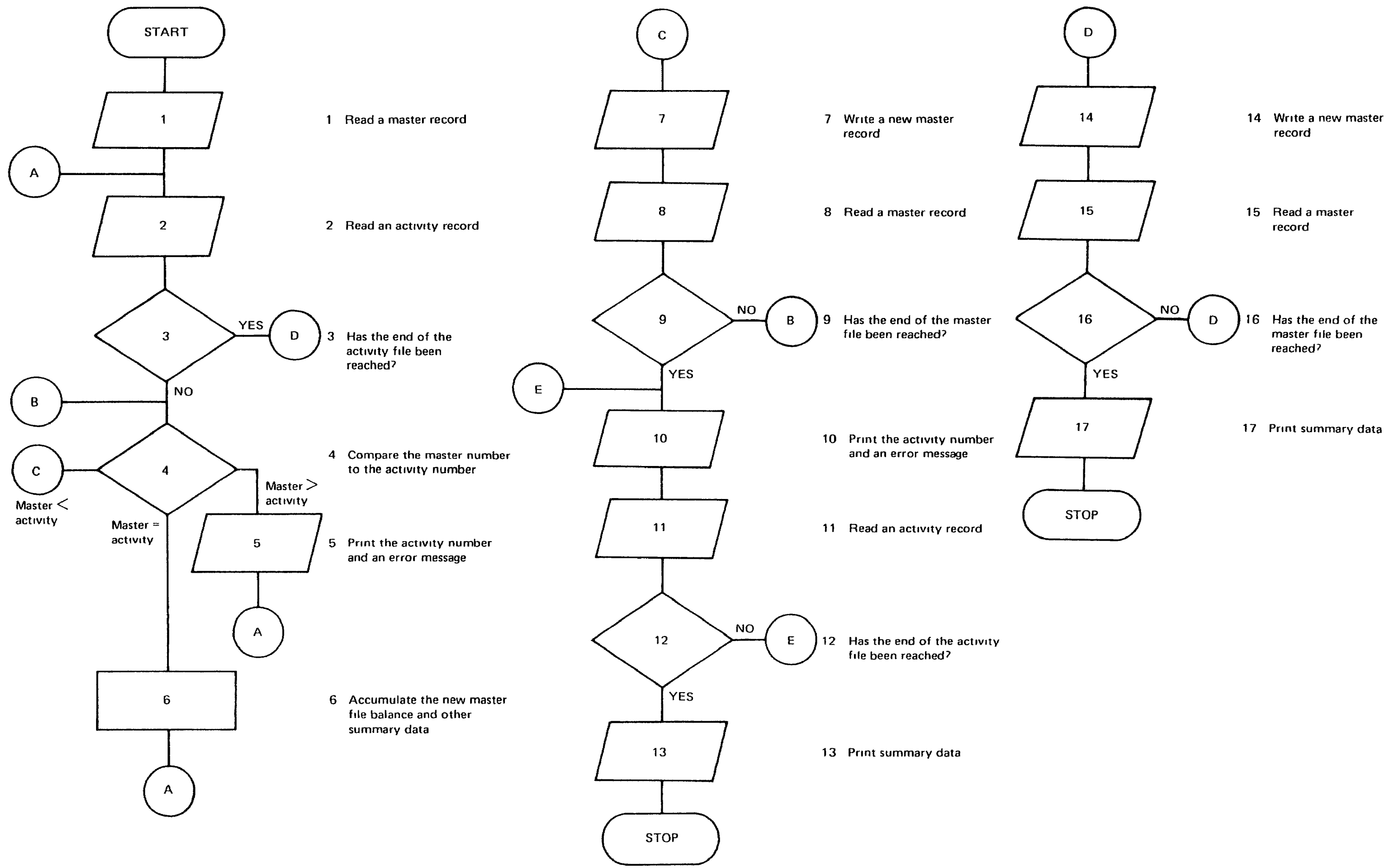


Fig. 6.3 A generalized file maintenance program flowchart.

When the end of the activity file is reached (Step 3) the program writes the previously read or updated master record (Step 14). Then, since there may be one or more master records which have not yet been processed, the program reads another master record (Step 15) and checks for the end of the master file (Step 16). If the record is a regular master record and not the end-of-file indicator, the program writes the record on the new master file (Step 14) and reads another master (Step 15). This loop is continued until the end-of-file indicator is reached, at which point the program prints whatever summary data it may have accumulated as part of Step 6 and stops execution. Note that the reading and writing of master records in this loop can continue without the need to check for activity, since it is known before this loop is entered that there are no remaining activity records.

It is also significant that the program execution as described above made no use of Steps 10 through 13 in the flowchart. These steps will in fact not be executed in most runs of the program, but they are necessary in the unlikely event that the end of the master file is reached prior to the end of the activity file. In such an instance the activity record being processed and all subsequent activity records are in error, since they cannot match with a master record. Thus if the end of the master file is reached prior to the end of the activity file (Step 9), an error message is printed indicating that there is no master record for the activity record in process (Step 10) and another activity record is read (Step 11). If the end-of-file check (Step 12) indicates that this next record is not the end-of-file indicator, the program loops back to again print the error message (Step 10) and read another activity record (Step 11). When the end-of-file indicator is read, the program prints out the summary data for the run (Step 13) and stops execution.

Decision tables. A *decision table* is a tabular representation of program logic which indicates the possible combinations of alternative logic conditions in the program and the corresponding courses of action taken by the program for each condition. A decision table may be prepared as an alternative or supplement to a program flowchart. They differ in that the program flowchart emphasizes the sequence of logical operations, while the decision table emphasizes alternative logic relationships among the data being processed.

The general form of the decision table is illustrated in Fig. 6.4. The upper half of the decision table is concerned with the various logic conditions which are tested for in the input data, while the lower half is concerned with the actions taken by the program for each set of conditions. The condition portion of the table consists of a number of horizontal rows, each of which represents one condition test within the program. The action portion of the table also consists of a number of horizontal rows, each representing an action taken within the program. The conditions or actions are written out in the left half, or stub portion of the table. The right half, or entry portion, of the table consists of a set of vertical columns, each representing one possible combination of logical relationships. Each such column is called a decision rule. Each entry in a

Condition stub	Condition entry
Action stub	Action entry

Fig. 6.4 General form of a decision table.

cell of the upper right quarter, or condition entry portion, of the table indicates the result of the condition test in that row within the decision rule of that column. Each entry in a cell of the lower right quarter, or action entry portion, of the table indicates whether or not the action in that row is executed if the decision rule in that column is met. These concepts are illustrated in the sample decision table of Fig. 6.5, which represents the file maintenance program flowcharted in Fig. 6.3.

The condition entries in a decision table may be in one of two forms. In the "limited entry" form, the condition test result may be either "yes" or "no," as, for example, with the condition test for end of activity in the illustration. In the "extended entry" form, more than two condition test results are possible, and the exact specifications of each result are indicated in the entry. If the illustration is taken as an example, in the comparison of master record and activity record account numbers, three results are possible: the master record account number may be (1) less than, (2) equal to, or (3) greater than the activity record account number.

The remaining condition entry illustrated in the table is the dash, or "don't care" entry. This indicates that the result of the condition test in that row makes no difference with respect to the decision rule of that column. For example, when the end of the activity file or the master file is reached in the sample program, a comparison of account numbers is no longer relevant. The "don't care" entry may appear in either an extended entry row or a limited entry row.

The entry in each cell of the action entry portion of the table may be either an "X" or a blank. An X indicates that the action described in that row is performed if the input data meet all of the condition test results specified in that column. A blank indicates that the action is not performed. Using the first column of the sample table as an illustration, if the input data represents neither the end of the activity file nor of the master file, and if the account number of the master record is less than that of the activity record, the program writes a new master record, reads a master record, and repeats the condition tests.

Several observations regarding the construction of decision tables are relevant. First, note that the decision rules in a table must be mutually exclusive,

End of activity	No	No	No	Yes	No	Yes
End of master	No	No	No	No	Yes	Yes
Compare account number Master vs activity	M<A	M=A	M>A	—	—	—
Print activity number and error message			X		X	
Update new master and summary data		X				
Write new master record	X			X		
Read an activity record		X	X		X	
Read a master record	X			X		
Print summary data						X
Stop processing						X
Repeat this table	X	X	X	X	X	

Fig. 6.5 Sample decision table for generalized file maintenance program.

which means that no decision rule should be repeated in the table. Second, the set of decision rules should be logically complete, which means that there should be one decision rule for every possible combination of logical relationships among the input data. Third, to the extent possible, the conditions listed in the condition stub portion of the table should be sequenced in the order in which the conditions are to be tested in the program, and the actions listed in the action stub should be sequenced in the order in which the actions are to be performed following the condition tests. This rule was followed in the table of Fig. 6.5, but cannot always be followed precisely. Finally, note that, for completeness, a decision table should include the action "repeat this table" if the program is designed to operate on more than one input record.

Decision tables provide some advantages and some disadvantages relative to program flowcharts as a tool in program planning. The primary advantage is that a decision table indicates clearly all of the possible logical relationships existing among the input data. As a result, the program can be prepared to recognize and respond properly to each possible decision rule. The primary disadvantage of decision tables relative to program flowcharts is that decision tables do not reflect the sequence in which operations are to be performed within the program. Another disadvantage of decision tables is that they may become unmanageably large if the program is quite complex. Program flowcharts are a more popular tool of program design than decision tables, but decision tables in many cases provide a useful supplement to program flowcharts.

Implementation. After the design of a computer program by means of a program flowchart and/or a decision table, the next step in program preparation is the actual writing of the program instructions in a computer language. This is referred to as *coding*. Coding is distinguished from programming in that the latter encompasses all of the steps involved in program preparation, whereas the former is only a single step. The program can usually be coded relatively easily by using the program flowchart or decision table as a reference.

Once the coding is completed, the program is keypunched onto a source deck. Visual review of a listing of the source deck for the purpose of discovering keypunching or programming errors is then performed. This visual review is a process known as *desk-checking* and is often more effective if performed by someone other than the original programmer.

The next step is to compile the program. If any programming errors exist in the program, the compilation run will provide *diagnostics*, which are codes or messages indicating the nature of each program error. The program errors are then corrected and the program resubmitted, with the process being repeated until successful compilation is achieved.

The next step is to test the program by devising a series of test input data which simulates all varieties of real processing situations or input data combinations to which the program may be exposed. The response of the program to each test case is observed, and an improper response indicates that the program contains some flaw, or "bug." *Debugging* is the process of discovering and eliminating an error in a program once its existence is known. Once all of its bugs have been removed, the program is ready for final compilation and utilization.

Another important step in program preparation is preparation of program documentation. The need for this step should be given attention throughout the program preparation process. For example, during the program coding, descriptive remarks should be inserted into the program where appropriate. System flowcharts, record layouts, program flowcharts, decision tables, and related items used in program preparation should be prepared according to prescribed standards and retained as part of the program documentation. At the completion of program preparation, the program documentation should also be complete and ready to be organized into a meaningful documentation manual.

Program Utilization

The pattern of utilization of a business data processing program over its life cycle depends upon the nature of the program. File maintenance and report generation programs are typically used on a regular schedule – once a day, once a week, or once a month. Information retrieval and online updating programs must be maintained online for utilization at any time, and the pattern of their utilization is often quite irregular. A problem-solving program is also likely to experience an irregular pattern of usage, and is commonly used less frequently than other kinds of programs because of its specialized nature.

During the period of years in which a program is utilized, any of a number of factors may at times require the revision of the program. This process is referred to as *program maintenance*. Examples of factors which may necessitate a specific change include: requests from managers for new reports, or for revisions in old reports; changes in program input or file content; change in some constant values, such as tax rates, which are part of the program; correction of a previously undiscovered bug; or modification to convert to new system hardware.

The period of utilization of a business data processing program varies widely, but will probably be no longer than six or seven years. A program may be made obsolete by the growth of a business or a change in information needs within the business, or perhaps by changes in system hardware or software. At this point its life cycle has come to an end and the program is discarded, replaced, or substantially revised.

Program Design Considerations

Now that the reader has gained some perspective on the development and use of computer programs in business and accounting applications, a brief discussion of the principles of program design is appropriate. The fact that a single program may be used for several years underscores the importance of careful program design. Three basic principles of program design will be discussed here.

The first and most important principle of program design is the principle of modularity. This principle dictates that programs be composed of *modules,* which are separate segments or subroutines within a program, each of which performs a separate logical function. For example, in a file maintenance program which processes several different types of transactions, there would be a separate module for each type of transaction. Each module should have only one entry point and one exit point to facilitate testing and changing of individual modules. Generally these modules should have no interaction with each other, interacting primarily if not exclusively with the program's "control module" or central logic section. In a file maintenance program the control module would be responsible for determining the type of each transaction and directing program control to the appropriate module.

Application of the principle of modularity begins in the flowcharting process. The proper approach to designing a complex program begins with the preparation of a *macroflowchart,* in which each symbol represents either a set of related program steps – a module – or a key control module step. Once a macroflowchart has been designed, preparation of the *microflowchart* showing each program step in detail can proceed more effectively. This process of designing a program from the top level down to the detailed level is often referred to as "hierarchical program design."

Successful application of the principle of modularity facilitates program design and utilization in several respects. Program preparation is made easier in many ways: flowcharting is simplified; coding is made easier and may even be split, with different programmers working on different modules; documentation is made easier; and debugging is facilitated because errors requiring correction of one module should not affect any other modules. Modularity also makes a program easier to review and understand because the control module provides a capsule summary of the entire program. Program maintenance is also easier to accomplish with modular programs.

The second basic principle of program design is the principle of generality. This principle requires that programs not be designed for only a single specific

task or set of requirements, but for the general case. This means that a program must be able to accommodate different sets of circumstances and changes in requirements. A general program will not generate unexpected errors, and therefore is likely to require less program maintenance.

The key to applying the principle of generality is thorough program planning and testing. Use of decision tables in program planning helps to ensure program generality, for a decision table may reveal unusual logical relationships which would not otherwise be planned for. A simple example of program steps which are necessary to provide a general program is furnished by Steps 10 through 13 in the file maintenance program flowchart of Fig. 6.3. These steps are necessary for the program to cope with unlikely and unexpected – but possible – characteristics of the input data.

The third basic principle of program design is that of maintainability. According to this principle, extra care in program design is justified if the program is made easier to maintain, because program maintenance will be necessary over a period of several years. As mentioned above, program maintenance is simplified with programs which are modular and general. Good documentation is also an essential factor in easily maintained programs.

EXAMPLES OF PROGRAMMING LANGUAGES

In this section, a brief overview of three of the most common procedure-oriented languages, FORTRAN, COBOL and BASIC, will be presented. This section is not intended to develop a working knowledge of those languages, but instead to provide a general knowledge of their basic characteristics. The primary purposes are to develop a perspective on the nature of procedure-oriented languages and to establish a basis for discussion of the relative merits of these languages, particularly FORTRAN and COBOL.

The FORTRAN Language

FORTRAN was the first procedure-oriented language to be widely used and accepted. The name FORTRAN is an acronym for FORmula TRANslator. Development of the language was begun in 1955, and it has evolved through a number of versions, including FORTRAN II and FORTRAN IV, the most recent version.

The FORTRAN language is oriented toward scientific data processing problems which can be expressed in terms of mathematical formulas. It can also be applied to other kinds of problems, including business data processing. It is still the most popular computer language, and most computers have available a FORTRAN compiler.

This brief overview of the characteristics of the FORTRAN language will employ the sample program shown in Fig. 6.6. The tasks which the program performs are: (1) reading the records of utility company customers, each of which contains the customer number, previous utility meter reading, and cur-

```
      PROGRAM UTILBILL
    1 FORMAT (I4,2F6.0)
    2 FORMAT (1X,I4,5X,F4.0,8X,F6.2,5X,F6.2,8X,F6.2)
    3 FORMAT (1H1,13X,23HCUSTOMER BILLING REPORT)
    4 FORMAT (2X,50HCUST      UTILITY    AMOUNT      AMOUNT     TOT AMT)
    5 FORMAT (2X,50HNO        USAGE      RATE-1      RATE-2     CHARGED)
   15 NTCR=0
      PRINT 3
      PRINT 4
      PRINT 5
   23 READ 1,NO,RD1,RD2
      IF (NO-9999)27,70,27
   27 USE=RD2-RD1
      IF (USE-500.)31,31,35
   31 AMT1=USE*.025
      AMT2=0.
      GO TO 40
   35 AMT1=500.*.025
      AMT2=(USE-500.)*.03
   40 TOT=AMT1+AMT2
      PRINT 2,NO,USE,AMT1,AMT2,TOT
      NTCR=NTCR+1
      IF (NTCR-30)23,15,15
   70 STOP
      END
```

Fig. 6.6 Sample FORTRAN Language program.

rent reading; (2) calculating the amount of each customer's utility bill; and (3) printing out a report containing this information. A FORTRAN program consists of a series of statements, some of which are numbered because they are referred to elsewhere in the program. The statements in a FORTRAN program can be classified into three basic types: input-output, control, and arithmetic.

Input and output operations in FORTRAN both must utilize the FORMAT statement which specifies the format in which the input data and output reports will appear. The READ statement, labeled number 23, performs the input operation in conjuction with the FORMAT statement labeled number 1. Output is accomplished by the use of the PRINT statement in conjunction with the FORMAT statement. The first three PRINT statements in the program result in the printing of headings for the output report, which are specified in FORMAT statements, numbers 3, 4, and 5. The PRINT statement near the bottom of the program, together with FORMAT statement number 2, perform the printing of output data for each customer.

Control statements regulate the sequence in which FORTRAN statements are executed. In the absence of control statements, the FORTRAN statements would be executed one at a time from top to bottom (except for FORMAT statements, which are not executed separately). The IF statement is one of the

control statements in FORTRAN. An IF statement is executed by evaluating the expression which appears in parenthesis following the IF. If the value of the expression is negative, control is transferred to the first statement number appearing after the parenthesis; if the value is zero, control transfers to the second statement number; and if the value is positive, to the third statement number. The GO TO statement directly transfers program control to the statement number indicated. Another common FORTRAN control statement which does not appear in the illustration is the DO statement, which establishes a loop in which a set of statements is executed over and over for a specified number of times. Another control statement is the STOP statement, which terminates the execution of the program.

Arithmetic statements accomplish the calculations in a FORTRAN program. All arithmetic statements appear in the form of an equation, with a single variable name to the left of the equal sign and one or more variables or numbers appearing on the right together with an indication of the operations (addition, multiplication, etc.) to be performed. The statement is executed by performing the operations on the right side, and setting the left side variable equal to the resulting value.

The COBOL Language

COBOL is an acronym for COmmon Business Oriented Language. As the acronym suggests, the language was designed specifically for business applications involving records processing and file updating. The language was developed in 1960 and 1961 by a committee containing representatives of computer manufacturers and large users, including the Federal government. This development group was referred to as CODASYL, an acronym for COnference on DAta SYstems Languages. COBOL is now the most common procedure-oriented language used for business data processing.

A sample COBOL program appears in Fig. 6.7. This program is designed to accomplish exactly the same task as the FORTRAN program in Fig. 6.6. Every COBOL program consists of four major divisions – the Identification, Environment, Data, and Procedure divisions, which must always appear in that order. The Identification division is only used for documentation purposes, and may contain only a program name. The Environment division describes the equipment configuration on which the program will be run, including the computer which will compile the program (the source computer), the computer which will execute the program (the object computer), and the devices which will be responsible for each input and output file.

The Data division specifies the format of each input and output file, and of each variable used in the program. In the sample program, the four lines under 01 USAGE-CARD describe the content of an input record to the program. The several lines under 01 PRINT-LINE describe the format of the output report. The lines under WORKING-STORAGE SECTION indicate

```
IDENTIFICATION DIVISION.
PROGRAM-ID. UTILITY BILLING.
REMARKS. PROGRAM COMPUTES A MONTHLY UTILITY BILL AND FORMATS A
    CUSTOMER BILLING REPORT.
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
SOURCE-COMPUTER. 3100 MEMORY 16K WORDS.
OBJECT-COMPUTER. 3100 MEMORY 16K WORDS.
SPECIAL-NAMES. PRINTER 61 IS PRTR.
INPUT-OUTPUT SECTION.
FILE-CONTROL. SELECT USAGE-FILE ASSIGN TO CARD-READER 60.
    SELECT PRINT-FILE ASSIGN TO PRINTER 61.
DATA DIVISION.
FILE SECTION.
FD USAGE-FILE LABEL RECORD IS OMITTED.
    DATA RECORD IS USAGE-CARD RECORD CONTAINS 80 CHARACTERS.
01 USAGE-CARD.
     2 CUST-NO                      PICTURE X(4).
     2 READ-1                       PICTURE 9(6).
     2 READ-2                       PICTURE 9(6).
     2 FILLER                       PICTURE X(64).
FD PRINT-FILE LABEL RECORD IS OMITTED DATA RECORD IS PRINT-LINE.
    RECORD CONTAINS 136 CHARACTERS.
01 PRINT-LINE.
     2 FILLER                       PICTURE X.
     2 CUST-NO-OUT                  PICTURE X(4).
     2 FILLER                       PICTURE X(5).
     2 USAGE-OUT                    PICTURE 9(4).
     2 FILLER                       PICTURE X(5).
     2 AMT-RATE-1                   PICTURE ZZZ9.99.
     2 FILLER                       PICTURE X(5).
     2 AMT-RATE-2                   PICTURE ZZZ9.99.
     2 FILLER                       PICTURE X(5).
     2 TOT-AMT-OUT                  PICTURE ZZZ9.99.
     2 FILLER                       PICTURE X(86).
WORKING-STORAGE SECTION.
    77 CTR                          PICTURE 99.
    77 NET                          PICTURE 9(6).
    77 AMT-R1                       PICTURE 9999V99.
    77 AMT-R2                       PICTURE 9999V99.
    77 NET-USAGE                    PICTURE 9(6).
    77 TOT-AMT                      PICTURE 9999V99.
PROCEDURE DIVISION.
START. OPEN INPUT USAGE-FILE OUTPUT PRINT-FILE.
HEAD-PROCEDURE. MOVE 0 TO CTR.
    DISPLAY '1            CUSTOMER BILLING REPORT' UPON PRTR.
    DISPLAY ' CUST     UTILITY    AMOUNT      AMOUNT     TOT AMT'
    UPON PRTR.
    DISPLAY ' NO       USAGE      RATE-1      RATE-2     CHARGED'
    UPON PRTR.
READ-USAGE. READ USAGE-FILE AT END GO TO FINISH.
COMPUTE-LOGIC.
    SUBTRACT READ-1 FROM READ-2 GIVING NET-USAGE.
    IF NET-USAGE IS GREATER THAN 500 PERFORM DISCOUNT
    ELSE PERFORM REG.
    ADD AMT-R1 TO AMT-R2 GIVING TOT-AMT GO TO PRINTT.
```

```
DISCOUNT.
    MULTIPLY 500 BY .025 GIVING AMT-R1.
    SUBTRACT 500 FROM NET-USAGE GIVING NET.
    MULTIPLY NET BY .03 GIVING AMT-R2.
REG.
    MULTIPLY NET-USAGE BY .025 GIVING AMT-R1.
    MOVE 0 TO AMT-R2.
PRINTT.
    MOVE SPACES TO PRINT-LINE MOVE NET-USAGE TO USAGE-OUT.
    MOVE TOT-AMT TO TOT-AMT-OUT. MOVE AMT-R1 TO AMT-RATE 1.
    MOVE AMT-R2 TO AMT-RATE-2 MOVE CUST-NO TO CUST-NO-OUT.
    WRITE PRINT-LINE ADD 1 TO CTR.
    IF CTR EQUALS 30 GO TO HEAD-PROCEDURE ELSE GO TO READ-USAGE.
FINISH. CLOSE USAGE-FILE, PRINT-FILE. STOP RUN.
END PROGRAM.
```

Fig. 6.7 Sample COBOL language program.

the specifications for all variables which are used in the program but are not contained in either an input or output file.

The Procedure division contains the actual instructions for processing. In the COBOL language these instructions are in the form of English language words, so that one can understand what the program does fairly well by reading the Procedure division. COBOL Procedure division statements perform the same set of functions as do FORTRAN statements. Input is accomplished in COBOL through the READ statement, and output through either the WRITE or DISPLAY statement. Control statements in COBOL include the IF and GO TO statements, which execute in a manner quite similar to their counterparts in FORTRAN. Arithmetic operations in COBOL are performed by statements such as those beginning ADD, SUBTRACT, or MULTIPLY.

A Comparison of FORTRAN and COBOL

A comparison of these two procedure-oriented languages should take into account the fact they were designed for different purposes. FORTRAN was designed for application to scientific problems. The use of mathematical notations, subscripts, formulas, and so forth is done more easily in FORTRAN than in COBOL. However, FORTRAN lacks many of the features that are desirable in a computer language for business and accounting applications, especially those involving the maintenance of files and the processing of complex data structures.

Despite its lack of orientation to business data processing, FORTRAN should not be completely ruled out for all business applications. FORTRAN would be most appropriate for the application of mathematical modeling techniques to the solution of business problems, or to any situation where the

amount of computation is significant while the input and output are simple in structure. For installations which have only limited requirements for file processing, the lack of availability of a COBOL compiler, or of programmers skilled in COBOL, may make it more appropriate to use FORTRAN even for file maintenance programs. For small installations making an initial decision to obtain a procedure-oriented language compiler, the fact that a working knowledge of FORTRAN is easier to develop may be significant. For most business organizations with a medium to large scale computer system, frequent usage of both languages would be likely.

There are several reasons why COBOL is a superior language for writing file maintenance and related programs. One of the major factors is the self-documenting nature of the language. Instruction verbs and related syntax in COBOL are very descriptive of the items they represent. This makes it much easier for a person other than the original programmer to understand what a given program is intended to accomplish.

As will be explained in more depth in a later chapter, the additional documentation provided by COBOL is also a significant factor in the accounting control of a computer system. Such audit functions as program review, monitoring of program changes, tracing of audit trails, and the preparation of test decks are faciliated by good documentation.

Some additional features of COBOL which serve to protect files from unintentional destruction include the provisions for assigning files to equipment in the Environment division and for automatic checking of file labels to guard against loading the wrong file for a job.

Since the processing of input and output is a major factor in business and accounting applications, the advanced features of the COBOL Data division are a significant advantage of COBOL relative to FORTRAN for this type of application. The Data division enables the establishment of a complex hierarchical file structure in which each record contains several fields, each field may contain several smaller fields, and so forth. Data editing provisions in COBOL facilitate the design of output reports having a very neat appearance, with dollar signs, debit and credit notation, commas, and so forth inserted where appropriate. Such provisions are not available in FORTRAN, which makes programming for input and output more difficult.

Although the writing of programs to accomplish simple tasks is easier with FORTRAN, the writing of complex file maintenance programs is easier and less time consuming with COBOL because of its self-documentation and because it enables separation of the programming effort between the writing of procedures and the description of input and output. The superior documentation provided by COBOL also: (1) facilitates communication among several programmers working on a single large project; (2) contributes to easier program testing and debugging; and (3) simplifies program maintenance over the life cycle of a program.

```
100 LET N=0
110 PRINT "             CUSTOMER BILLING REPORT"
115 PRINT
120 PRINT "CUSTOMER  UTILITY  AMOUNT   AMOUNT   TOT AMT"
130 PRINT " NUMBER    USAGE   RATE-1   RATE-2   CHARGED"
140 READ N1,R1,R2
150 IF N1=9999 THEN 280
160 LET U=R2-R1
170 IF U>500 THEN 210
180 LET A1=U*0.025
190 LET A2=0
200 GO TO 230
210 LET A1=12.5
220 LET A2=(U-500)*0.03
230 LET T=A1+A2
240 PRINT USING 245,N1,U,"$",,A1,"$",A2,"$",T
245:  ####     #####    '##.##    '##.##    '###.##
250 LET N=N+1
260 IF N=30 THEN 100
270 GO TO 140
280 STOP
290 DATA 123,4700,5500,124,6300,6650,9999,0,0
300 END
```

Fig. 6.8 Sample BASIC language program.

The BASIC Language

BASIC is an acronym for Beginner's All-purpose Symbolic Instruction Code. As the acronym implies the language was designed to be very simple to learn so that nonprogrammers could easily use it. It bears a close resemblance to FORTRAN, although it is simpler and easier to learn than FORTRAN. BASIC is perhaps the most commonly used language among those who rent time-sharing services for purposes of solving small mathematical problems with a computer.

A sample BASIC program appears in Fig. 6.8. Once again, this is a program written to accomplish the same task as those in Figs. 6.6 and 6.7. Note that all statements in BASIC must be numbered, and they are arranged in numerical order, which is not true of FORTRAN. READ statements together with DATA statements are one primary means of data input, and the PRINT statement is used for output. The IF and GO TO statements perform control functions as in FORTRAN. Mathematical expressions are prefaced with LET. Very few conventions have to be learned to obtain a working knowledge of BASIC, but the language is lacking in some of the advanced features of FORTRAN.

One of the special characteristics of BASIC is the INPUT verb (not shown in Fig. 6.6) which enables *conversational programs* to be written. Such programs interact with a user at a remote terminal by printing questions for him to type in answers to, or printing requests for specific data. After the user responds, the program continues its execution in accordance with the responses, and may subsequently print output and/or ask for more input from the user. The INPUT verb performs the functions of stopping program execution while the user responds and of reading his responses.

Although the BASIC language, like FORTRAN, is inappropriate relative to COBOL for file maintenance applications, it has many potential applications to mathematical problem solving in accounting. In fact, its simplicity gives it a significant advantage over FORTRAN for this purpose, since most accountants will not use such a language enough to justify an extensive learning effort. A common use of BASIC in accounting involves the programming of financial planning models, which simulate the financial aspects of a firm's operations for one or more years into the future. The interactive capability of the language enables such programs to be easily used by nontechnical persons, such as top management executives. Other areas of accounting in which BASIC is useful include tax planning and cost analysis.

Other Languages

The total number of procedure-oriented languages is slightly greater than one hundred. To give some idea of the variety of such languages that is available, a few of them will be briefly mentioned here.

One very popular scientific language is ALGOL (ALGOrithmic Language). A language which is common in small installations with business applications is RPG (Report Program Generator). A language which was designed by IBM to incorporate features of both COBOL and FORTRAN is PL/1 (Programming Language I). A language offered by IBM for time sharing is APL (A Programming Language). Several languages designed specifically for simulation problems include SIMSCRIPT, DYNAMO, and GPSS (General Purpose Systems Simulator).

REVIEW QUESTIONS

1. Define the following terms:

programming	record layout
machine language	program flowchart
symbolic language	block diagram
procedure-oriented language	decision table
assembler	coding
source program	desk checking
object program	diagnostic
macroinstruction	debugging
machine independent	program maintenance
compiler	module
utility routine	macroflowchart
library routine	microflowchart
operating system	conversational program

2. List, describe, and give some examples of several major categories of computer software.

3. Why is it uncommon for a programmer to use machine language in writing a program?
4. Can a computer directly execute a symbolic language program? Explain.
5. What are the advantages and disadvantages of procedure-oriented languages relative to symbolic languages?
6. What are some of the characteristics of a data processing installation which would influence the decision of whether to program in symbolic language or in a procedure-oriented language?
7. List, describe, and give examples of four types of application programs common in business data processing.
8. What are some examples of the different types of file activity processed in file maintenance programs?
9. What does "unbundling" mean, and what is its significance to computer software?
10. What are the essential elements of system documentation for computer system applications?
11. Describe two ways in which the application of computers in accounting has influenced the development of computer software.
12. Describe the steps in the preparation of a computer program.
13. Identify the symbols used in program flowcharting, indicate the meaning of each, and describe or give an example of the usage of each.
14. In all batch processing file maintenance programs, one essential step is a comparison of the identifying number of the master record with that of the activity record. What are the three possible outcomes of this comparison? Explain one possible meaning of each outcome.
15. Describe the format of a decision table.
16. Distinguish between the "limited entry" and "extended entry" form of a decision table.
17. Describe the primary advantages and disadvantages of decision tables relative to program flowcharts as a tool of program preparation.
18. Distinguish between file maintenance and program maintenance and give an example of each.
19. Explain three basic principles of program design.
20. What are the phrases for which FORTRAN, COBOL, and BASIC are acronyms?
21. What are three basic types of statements in the FORTRAN language? Give an example of each.
22. What are the four divisions of a COBOL program and what is the purpose of each?

23. What years mark the beginning of development of the FORTRAN and COBOL languages?
24. Describe the advantages of FORTRAN relative to COBOL for programming of mathematical and scientific problems.
25. For what kind of business situations would FORTRAN be more appropriate than COBOL?
26. Describe the advantages of COBOL relative to FORTRAN for writing file maintenance programs.
27. How can the use of COBOL contribute to the internal control of a computer system?
28. For what general purpose is BASIC most commonly used? Give some specific examples of applications for this language in accounting.
29. Name six procedure-oriented languages in addition to COBOL, FORTRAN, and BASIC.

DISCUSSION QUESTIONS

30. Should the student of business be first taught the FORTRAN, BASIC, or COBOL language? Discuss.
31. If the definition of computer software were to be restricted to programs, would you consider programming languages to be a form of software? Why or why not?
32. Is it necessary for an accountant in a firm which uses computers extensively in data processing to have either (a) some knowledge of, or (b) an expert's knowledge of, programming in a language such as COBOL? Discuss.
33. Is it necessary for an auditor working for a public accounting firm to have either (a) some knowledge of, or (b) an expert's knowledge of, programming in a language such as COBOL? Discuss.

PROBLEMS AND CASES

34. Prepare a program flowchart of the illustrative program of this chapter (see Figs. 6.6, 6.7, or 6.8).
35. The Hi - Lo Manufacturing Company utilizes a medium-sized computer system for data processing. Compilers for both the FORTRAN and COBOL languages are available, as are programmers who specialize in each language.

    The Company has decided to write a computer program to analyze its monthly financial statements. Input to the program would consist of detailed balance sheets and income statements for the current and preceding months. The program would calculate various ratios, percentages, growth rates, etc., and print out an analysis in the form of several schedules. The program would, of course, be run once monthly.

What arguments could be made favoring the use of COBOL in writing this program? of FORTRAN? Explain.

36. This exercise involves tracing the operations performed on a hypothetical set of master and activity records through the program flowchart of Fig. 6.3, p. 159. Assume that the master file and activity file are composed of the record numbers shown below in the sequence given:

Master: 011, 013, 014, 015, 016, 017, 018, 019, EOF
Activity: 011, 012, 014, 014, 016, 018, EOF

a) Construct a table containing five columns with headings as follows: Read Master, Read Activity, Match, Write Master, Write Error. Begin tracing the records above through the program. Each time a record is read, a match is found between a master and activity record, or a record is written, write down the identifying number of the record in the appropriate column of the table. Number each item that you write in the table in sequence beginning with one. Continue until you have traced all records through the program.
b) Assume that there had been an activity record with the number 020 after record number 018 and in front of the end-of-file record. Beginning at the point at which this change would first have made a difference, trace the records through the program to the finish, recording in your table as described above.

37. Prepare a program flowchart and a decision table for the program described below.

Input to the program consists of records in an inventory file, each of which contains the item number, quantity on hand, price, and total cost of an inventory item. At the beginning of processing, and after every fifty lines of output, the program prints a set of report headings.

For each input record, the program calculates the product of price and quantity on hand and then compares this product with the total cost. If the product and total cost do not agree, the item number and an error message are printed out on one line. If the product and total cost do agree, the four items of data in each record are printed out, along with a message, on one line of the report. The message field contains blank spaces if the total cost of the item is less than $1,000; otherwise the message is used to place the label "high value item" beside the item.

When the end of the inventory file is reached, processing is halted.

38. From the description below of the processing of casualty claims by an insurance company, prepare: (1) a system flowchart; (2) a program flowchart of the file maintenance program; and (3) a decision table of the file maintenance program.

The data processing section maintains on magnetic tape a master file of all outstanding claims in sequence by claim number which it updates daily. Input to this computer run, in addition to the master file, consists of two types of transactions-records of newly-filed claims, and

authorizations to pay existing claims. These transactions are keypunched and verified from source documents provided by the claims department. The resulting punched cards are converted to tape on the computer. The conversion run generates a printed report of batch totals which is compared to batch totals provided by the claims department on an adding machine tape.

The transaction tape is sorted and processed against the claims master by the file maintenance program. Output of this run consists of: (1) the updated claims master, which contains only unpaid claims; (2) checks in payment of all claims as authorized; and (3) an error list and financial summary report. Among the errors listed on the latter report are invalid transactions, including payment authorizations for which no claim exists on the file, and new claims having the same claim number as claims already on the file.

After the file maintenance run is completed, the claims master file is processed by a report generation program to prepare a report of outstanding claims for the claims department.

39. From the description below of the processing of patient charges by a hospital, prepare a block diagram.

The data processing section maintains on magnetic tape a master file of charges for all patients. This file is updated daily in a computer run, the input to which consists of punched cards sorted into sequence by social security number of the patient. (The master file is also in this sequence.) Punched cards relating to an individual patient may be a record of admittance, a charge, or a notice of release, in that order. To simplify matters, you may assume that an admittance and release for the same patient are never processed together in the same run. The computer run generates an updated master file containing a record of each in-patient and all of his accumulated charges to date, and also a printed report listing error transactions and summary information. When a notice of release is included, the program prints a report of all accumulated charges for the patient, and does not include this patient's record in the updated master file.

40. Prepare a program flowchart for the inventory file updating process described below.

The master inventory file is on magnetic tape, and contains the inventory part number, a description, and the quantity on hand. The file is in part number sequence. Inventory transactions are on punched cards, and include: (1) new inventory items for which a record is to be created in the file; (2) receipts; and (3) issues. Prior to processing, the transaction cards are sorted into part number sequence. In the event that more than one transaction type exists for a particular inventory item, the transaction types are sequenced in the order given above. During processing, receipts

are added to the inventory balance of each item and issues are deducted, and a new updated master file is generated on magnetic tape. Two printed reports are also prepared, which are a stock status report listing the contents of the updated master file and a listing of error transactions and summary information.

Chapter 7

Real-Time Systems

In Chapter 5 the subject of online processing was discussed and contrasted with batch processing. In this chapter a particular type of online system known as *real-time system* will be discussed, with emphasis on the hardware and software components and on the business applications of such systems. A real-time system is defined as a data processing system or subsystem in which the time interval required to process and respond to input data is so small that the response itself is useful in controlling a physical activity or process.

An important concept in the definition of a real-time system is the concept of response time, or the time interval between data input and system response. Real-time systems are sometimes associated with immediate response. However, the length of response time which will qualify a given system as real-time is actually dependent upon the nature of the physical activity being controlled by the system. If the activity is the launching of a space satellite, a response time measured in fractions of a second is necessary in order for the system to control the activity effectively. If the activity is within a business environment, a response time of several seconds or even a few minutes may be adequate for control purposes. Thus the nature of the activity being controlled determines the response time necessary for a real-time system to effect control.

Two other aspects of the definition of real-time system deserve comment at this point. First, note that the response of a real-time system is a form of feedback, and a real-time system is therefore one type of feedback control system. Second, it should also be noted that most real-time systems, particularly those in business, are subsystems of larger data processing systems. The real-time subsystem may only be applied to one particular activity, while processing related to all other activities in the organization is accomplished in batch mode. Both the real-time and batch processing applications would share the same central computer.

It is necessary to distinguish between real-time systems and online systems. A real-time system must have an online capability; that is, the capability of direct access to file storage from locations at which input data originate. However, online capability alone is not sufficient to qualify a system as real-time.

The system must also contain hardware and programs which enable it to process input and generate a response which is useful for control purposes. Thus a real-time system is one type of online system. In fact, some authorities refer to real-time systems as "on-line - real-time (OLRT)" systems.

Two forms of online processing described in Chapter 5 were online updating and inquiry processing. Generally, online updating alone is not a form of real-time processing, because all that is accomplished in online updating is the updating of a record. The concept of online updating does not imply a system response. However, many real-time systems also perform online updating in conjunction with their real-time operation. On the other hand, inquiry processing is a form of real-time processing in cases where the response to the inquiry meets the condition of being timely enough to be useful for control purposes.

In addition to online updating and inquiry processing, a third function commonly performed by a real-time system is the initiation of a transaction as the by-product of another processing step. For example, after receiving data on a sale transaction, the system might print a shipping order authorizing delivery of the goods sold. As another example, the system might prepare a purchase requisition after receiving data on usage of raw materials. This function is called *dispatching,* and requires a very sophisticated real-time system. An even more sophisticated real-time system may actually perform the function of managing the operation of a process by scheduling activities or blending raw materials in an optimum manner.

Real-time systems are singled out for special study here because they offer accountants and others in business the chance to fulfill the potential of the computer as a tool of management. The reader will discover that real-time systems are also much more complex than conventional computer systems. The chapter will first discuss some of the complexities of the hardware and software in a real-time system, with special emphasis on the cost-performance trade-offs which affect system design. Then an analysis on some applications of real-time systems in business and accounting will follow.

HARDWARE FOR REAL-TIME SYSTEMS

The hardware required in a real-time computer system includes, in addition to the central processor, online file storage devices, data terminals located at major points of system usage, and a data communications network to connect the terminals with the central processor. Varying degrees of complexity are possible in the basic hardware configuration. The simplest configuration is illustrated in Fig. 7.1. In this configuration several[1] input-output terminals are linked directly to a central processor. A system of this type is called a *simplex system* because there is only one central processor. A simplex system cannot

[1]In Fig. 7.1 and the subsequent illustrations only three terminals are shown, though the actual number may vary from 3 to 100 or more in very large systems.

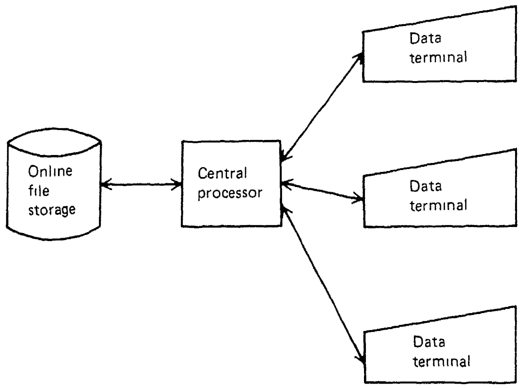


Fig. 7.1 Simplex system.

be available for use at all times because of the necessity for regular preventive maintenance of the central processor, and because of the inevitability of occasional equipment malfunctions. Provisions for a manual backup system are thus necessary. To offset these disadvantages, however, the simplex system offers the advantage of real-time capability at the lowest possible cost and with a minimum of complexity in hardware and software system design.

A somewhat more complex real-time configuration is illustrated in Fig. 7.2. This is still a simplex system, but a *multiplexor* has been added to the data communications network. The multiplexor is a device responsible for controlling the communications between several terminals and the central processor. The multiplexor serves as a buffer between the CPU and the terminals, storing input data until called for by the CPU and receiving output data from the CPU for transfer to the terminals, thereby relieving the CPU of these communications functions. If the data terminals are situated at several geographically scattered locations, one or more multiplexors may be installed at locations close to the terminals which enables several long-distance communication lines to be replaced by one long-distance line and several shorter lines. Some multiplexors are actually specialized computers having their own stored program which performs input-output functions relating to terminals for the central processor. In some cases the multiplexor may be able to perform some functions even while the central processor is down. For example, it could route a message from one terminal to another, though it could not access files or perform computations independent of the central processor.

The primary advantage of using a multiplexor in a real-time system is the saving in communications costs which is possible from reducing the number of long-distance communication lines between remote terminals and the central processor. Another advantage is that system design considerations relating to the central processor are simplified. The main disadvantages of the multi-

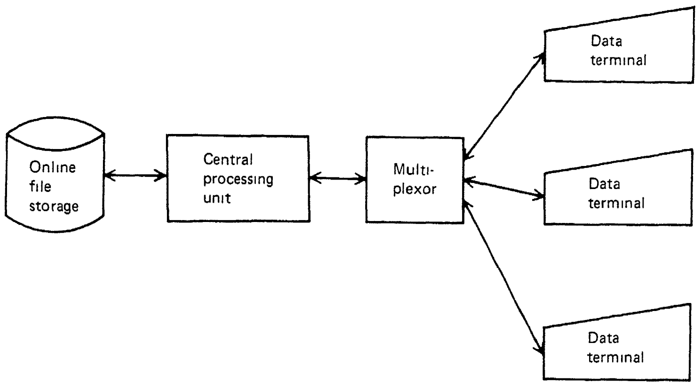


Fig. 7.2 Simplex system with multiplexor.

plexor are its extra cost and the increased system complexity which results from adding one more element capable of breaking down or causing errors in data transmission.

Several real-time configurations utilize more than one central processor to maximize the availability and reliability of the system. Two such systems which are best suited for business applications will be described here. The first of these is the *duplex system* illustrated in Fig. 7.3. This configuration uses two central processors, the second of which can take over for the first during its scheduled maintenance or during an equipment failure. When the second computer is not substituting for the first, it generally performs batch processing or other jobs. The advantage of the duplex system is that it greatly increases the degree of availability of the system, which is a very important factor in some real-time systems. The major disadvantages are the increased system cost and the increased complexity of the software system required to accomplish the switchover of operations from one computer to the other.

A second configuration using more than one central processor is the *multiprocessing system,* one example of which is illustrated in Fig. 7.4. This system utilizes two or more computers, and each computer is specialized to perform a particular set of functions. Each transaction entered into the system is routed to the computer intended for handling that operation. This configuration also provides for maximizing the availability of each system by transferring the work of one computer to another when the first is undergoing preventive maintenance or suffering a malfunction. However, when one computer is down, another will be performing more than one set of functions, which usually results in some decrease in the quality of service.

Both the duplex and multiprocessing systems can be justified only in large organizations having high-volume real-time applications. The duplex system is

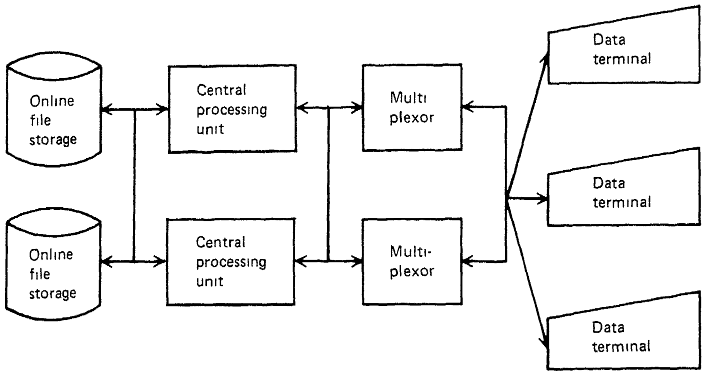


Fig. 7.3 Duplex system.

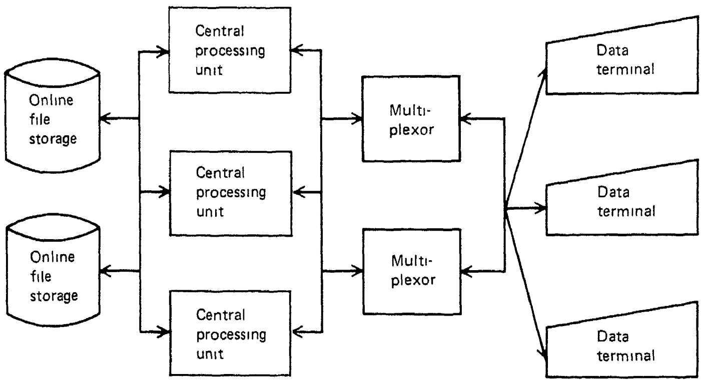


Fig. 7.4 Multiprocessing system.

more appropriate when there is only one major real-time application requiring a high level of system availability. The multiprocessing system is more appropriate when multiple real-time applications exist. Alternatively, the multiprocessing system may be used for a single application in which there is a very wide geographical dispersion of input sources. In this case each computer would specialize in processing transactions from a particular geographical area rather than concentrating on a particular set of functions. Both of these configurations are used in business, and the suitability of either for a particular organization depends upon the peculiar circumstances of each case.

The remainder of this section will discuss briefly some of the primary characteristics of each of the four major hardware components of a real-time system.

The Central Processor

Certain features of real-time operation demand that the central processor have capacity and capability beyond that required for simple batch processing operations. For one thing, the CPU must be capable of operating in a multiprogramming environment, because a real-time system must handle many different activities at the same time. In addition, the control logic of the CPU must be capable of handling *program interrupts,* which are temporary stoppages in the execution of one program by the CPU in order that it can process a higher priority message or transaction which has demanded attention.

Many of the features required of a computer performing real-time applications relate to the primary memory within the CPU. The most obvious requirement is for a larger memory capacity so that interrupted programs and data from uncompleted transactions can be stored while awaiting the attention of the computer. It is also desirable that the CPU have special features which facilitate the allocation of memory for various purposes and which keep track of committed and uncommitted memory blocks. Special features for memory protection are also essential to prevent the transfer of data into a memory area which is already in use. A well-planned system should also be capable of expanding by adding additional main memory units when needed.

Online File Storage

The file storage medium for a real-time application must have random access capability. The two most common choices are magnetic disk and magnetic drum. Choice between these two alternatives involves a trade-off between speed and cost factors. Recall from Chapter 5 that drum storage provides a faster access time than disk, but is also more expensive per item of stored data.

Three of the primary system characteristics affecting the choice between disk and drum storage are the desired response time, the frequency of reference to the files, and the file size. If an extremely fast response is desired, drum storage may be more appropriate. In most business applications a difference of a fraction of a second in response time will make no difference. If there is a high frequency of references to a file, overall system efficiency may be improved by maintaining that file on the faster access drum. If the size of the files is very large, disk storage may be favored because of its greater economy. In many large real-time systems, these various considerations are compromised by use of both disk and drum storage.

Another significant consideration relating to file storage in a real-time system is the provision for backup storage. In some systems in which constant availability of service is essential, duplicate files may be maintained. This is

very expensive, not only because of the duplicate storage device, but also because of the additional complexity of the software and the additional consumption of time to update both files. A less expensive alternative is to use disk file units with removable disk packs. Then if the file unit itself goes down, the disk pack can be removed and placed onto a backup file unit. If system availability at all times is not crucial, the system may be designed to reject file inquiries relating to a file which is down, though it may be possible to store file updates on another medium, such as tape, and process them once the file is restored to service.

Data Terminals

The data terminal in a real-time system represents the point of interface between man and machine, and is therefore one of the more significant factors in the success of the system. There are two basic categories of terminals: (1) teleprinters; and (2) cathode ray tubes (CRTs), or display terminals. The latter may be either alphanumeric displays, which specialize in alphanumeric input and output (see Fig. 5.16), or graphic displays, which have the capability of displaying graphs and charts. Graphic display terminals are much more commonly used in engineering applications than in business, but their usage in business is growing. An example of a business-oriented graphics terminal is illustrated in Fig. 7.5.

Several factors influence the choice between teleprinters and alphanumeric displays in a real-time system. Cost considerations relating to the terminal alone favor the teleprinter, the cost of which may range from \$600 to \$3,000, as compared to a range of \$1,000 to \$10,000 for display terminals. Another factor favoring the teleprinter is that it automatically produces a paper copy of all input and output. Some display terminals have special units which will produce a copy of whatever is on the screen when desired, as exemplified by the unit shown in Fig. 7.5. Others are capable of storing internally more lines of data than can fit on the screen at any one time, in order that the operator can refer back to such data after it leaves the screen. However, both of these features significantly increase the cost of the display terminal. Primarily because of the cost factor, teleprinters are more common than display terminals in business usage at the present time.

Display terminals do possess several advantages over teleprinters and it has been predicted that their usage will grow to the point of being equal with the usage of teleprinters within a few years. One major advantage is the capability of displaying a format to facilitate data entry. For example, the terminal might display the format of a sales order to be filled in by a salesman. This makes it very easy for an operator, with perhaps very little training, to enter all of the pertinent data relating to a transaction. Another advantage of display terminals over teleprinters is that the correction of errors in entered data is easier to perform. In addition, CRT displays are much less noisy than teleprinters. Still another advantage of display terminals is output speed, which becomes very

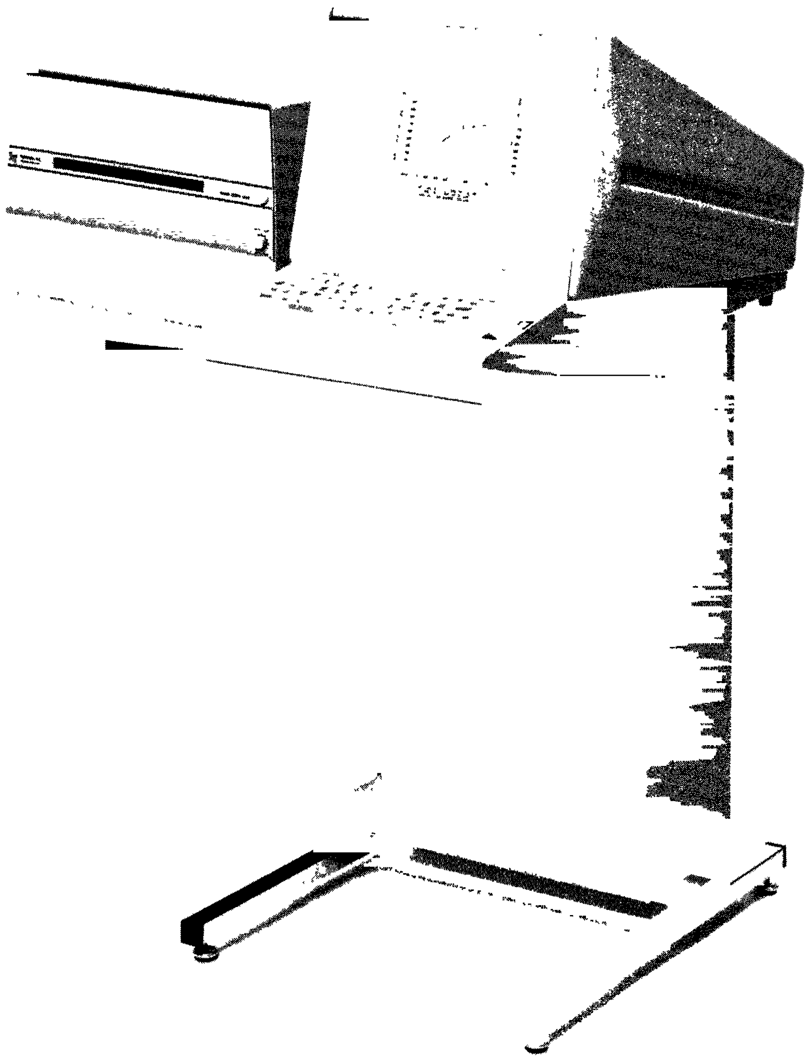


Fig. 7.5 Business-oriented graphics terminal with attached hard copy unit. (Courtesy of Tektronix, Inc.)

significant if output quantities are large. The typical printing speed of a teleprinter is 15 characters per second, while CRT output speeds range from 60 to 240 characters per second.

In some cases the cost savings and other advantages of online data entry may represent the primary justification for a real-time system. The main advantage of such a system is that files are up to date at all times, which facilitates management control in several ways. In addition, several other advantages are obtained. When an application is converted from batch processing to real-time, the equipment and personnel necessary for keypunching and verification are eliminated. The time-consuming operations of card reading and record sorting are no longer necessary. The time required for employees to fill out source documents is instead used for entering source data on the terminals, so that no increase in personnel is necessary. The possibility of errors in transcribing data from source documents onto cards, or loss of source documents in transit, is eliminated. The possibility of omission of relevant data from source documents is eliminated, because the computer can be programmed to accept only complete entries and ask for additional data if necessary. The possibility of erroneous source data entry is reduced, because the computer can evaluate the reasonableness of critical data, the validity of record keys such as account numbers, and perform various other checks on the input.

Offsetting the advantages of online data entry listed above are the additional costs of the terminals and data communications facilities. It is likely that a real-time system will require more terminals than the number of keypunches it replaces because of the geographical dispersion of sources of data input and the slower speed of the operators. In most cases, however, more than one operator can share a single terminal. Another unfavorable factor is that the accuracy of data input in a real-time system is closely related to the degree of care which terminal operators are willing to take in entering and checking data. The decision of whether the cost savings and other advantages of online data entry outweigh the additional costs and other disadvantages must be based upon the unique circumstances of each individual case.

Data Communications

The transmission of data from remote terminals to a central processor is generally accomplished through the facilities of the communications companies, the largest of which in the United States are the Bell System and Western Union. These carriers may transmit data by microwave, cable, or even open-wire telephone lines, though the latter are not reliable and have generally been phased out for data transmission. In a few real-time systems in which all terminals are within a short distance (a few miles or less) of the central processor, use of carrier facilities is not necessary.

The carriers offer several choices of services to their data communications customers. With respect to speed of data transmission, communication lines fall into one of three categories. These are: (1) *subvoice grade,* with speeds ranging

up to 200 bits per second (bps), (2) *voice grade*, or normal telephone lines, with speeds ranging from 600 to 4,800 bps, and (3) *wide-band*, with speeds ranging from 20,000 to 500,000 bps. The higher the speed of transmission of a line, the higher is its cost.

The carriers offer two basic options with respect to usage of facilities, which are leased or private lines, and switched lines or dial-up service. Leased lines are devoted exclusively to the use of a single customer. Dial-up involves simply using the long-distance telephone service available to the general public. The cost of a leased line is fixed and is determined by the length of the line. The cost of dial-up is variable with usage. Therefore dial-up service is less costly than a leased line up to a break-even volume, beyond which the leased line is more economical. Other factors in the choice between these two types of service include: transmission speed, which is generally greater over leased lines; error rates, which are generally smaller over leased lines; and flexibility, which is present when dial-up service is used in the sense that more than one system can be accessed from a single terminal.

The transmission of data over telephone lines is a form of analog transmission, in which signals are continuously variable, resembling waves. Computers generally only recognize digital transmission, in which signals are discretely variable. Examples of these two types of signals are shown in Fig. 7.6. In a data communications system, digital signals must be converted to analog form, which is called *modulation,* and then analog signals must be converted back to digital form, which is *demodulation.* The device used to accomplish this task, both at the site of the computer and at the site of the terminal, is called a *modem,* which is an acronym for MOdulator - DEModulator. Most modems (also called *data sets*) are separate units physically from terminals and computer CPUs (see Fig. 7.7). However, it has recently become possible to purchase terminals with modems incorporated into them. The latter arrangement offers the advantages of lower cost, increased reliability, and a reduction in complexity of the data communications network.

The network of communication lines which connects a centrally located computer with several geographically remote terminals may be configured in a number of ways. Three basic categories of configurations are: point-to-point lines, multidrop lines, and concentration of lines in a central location, such as by use of a multiplexor. The simplest alternative is the use of point-to-point lines, involving one line from each terminal to the central processor, as illustrated for an assumed system of terminals diagramed in Fig. 7.8. The use of *multidrop lines*, illustrated in Fig. 7.9 for a set of terminals having the same relative relationship as those in Fig. 7.8, involves linking the terminals to each other, with only one or a few terminals linked directly to the CPU. All other terminals are indirectly linked to the CPU by means of lines which connect through other terminal locations. The use of a multiplexor, described earlier in this chapter, is illustrated with the same set of terminals in Fig. 7.10.

In a system using point-to-point lines, each line may be either leased or switched, whichever is most economical. Therefore, such a system may have

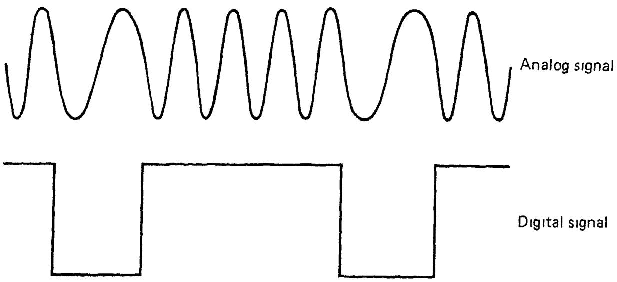


Fig. 7.6 Analog and digital signals contrasted.

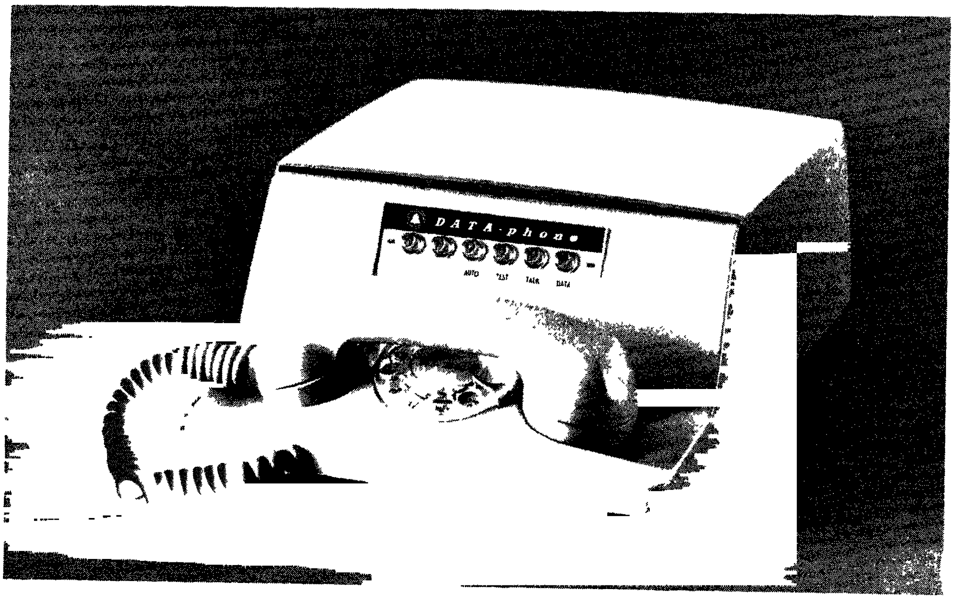


Fig. 7.7 Telephone with modem for data transmission. (Courtesy of Southwestern Bell Telephone Company.)

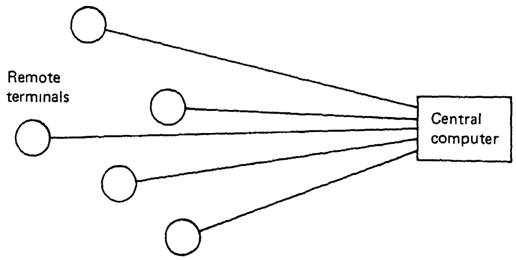


Fig. 7.8 Data communications network using point-to-point lines.

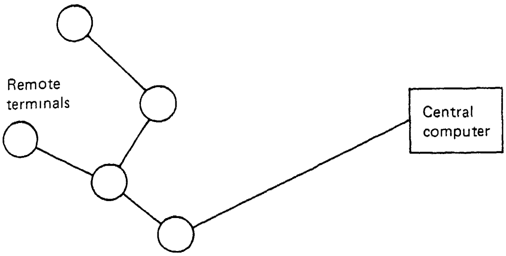


Fig. 7.9 Data communications network using multidrop lines.

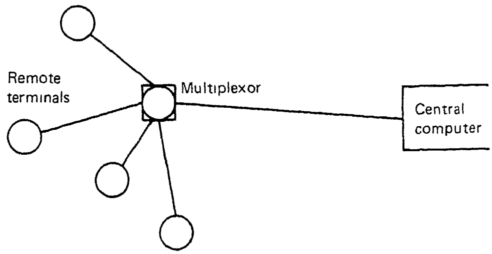


Fig. 7.10 Data communications network with multiplexor.

some leased lines and some switched lines. The advantages of this configuration over the others are: (1) its simplicity in terms of hardware requirements; (2) its increased availability to users, who will never be required to wait for service because other users have tied up the lines; and (3) its reliability in the sense that, if a line fails, only one user is affected. The primary disadvantage of this configuration is that it maximizes total line mileage in the network. Since most elements of data communications cost are directly related to line mileage, this means that point-to-point lines are frequently more costly than alternative configurations.

A visual comparison of Fig. 7.8 with Fig. 7.9 should illustrate the potential for reduction in line mileage from the use of multidrop lines. However, the cost saving inherent in the reduction may be either partially or wholly offset by the cost of the additional hardware required with multidrop lines. This additional hardware consists of one or more line control units which serve as an interface between two or more terminals and the CPU. Another disadvantage of a multidrop configuration involves its effect upon the reliability of a system. For example, if a line fails at a certain point in a multidrop configuration, then all terminals down the line from that point are cut off from the CPU.

The use of a multiplexor in a data communications network also reduces total line mileage relative to a system using point-to-point lines. This is evident from a visual comparison of Fig. 7.8 with Fig. 7.10. However, the cost saving generated by this reduction in line mileage is once again either partially or wholly offset, this time by the cost of the multiplexor itself. Furthermore, in a configuration using a multiplexor, the system may at peak periods be unavailable to some users if all lines from the multiplexor to the CPU are tied up by other users.

In comparing configurations using multidrop lines with those using a multiplexor, it is generally true that the multidrop configuration minimizes total line mileage though the magnitude of the difference is often not significant. The extra hardware required for multidrop lines is generally not as expensive as a multiplexor. However, the use of a multiplexor may enable substantial economizing on line cost by means of using switched lines rather than leased lines to

connect individual terminals to the multiplexor. Such considerations as reliability, system availability, and flexibility may also enter into the comparison. Even at that, it is possible for a system having a large network of terminals to use point-to-point lines for some terminals, multidrop lines for others, and a multiplexor for others.

The degree of sophistication available in multiplexors varies widely. A simple multiplexor may only be capable of transmitting messages received from several channels over a single channel, and vice versa. Generally, as the distance between the central computer and the multiplexor increases, the more desirable it is to utilize a multiplexor capable of performing more functions on its own. The multiplexor may even be a small stored program computer capable of requesting input from terminals and performing a limited number of operations on input received from terminals. The greater the number of functions which can be performed by the multiplexor alone, the fewer are the number of messages which have to be transmitted between the multiplexor and central computer.

To carry this concept even further, large organizations may find it desirable to utilize a system in which a large central computer is connected to several small computers at remote locations. The small peripheral computer systems would not only perform multiplexing for applications requiring access to the central computer and its files, but would also perform some applications, such as batch processing, on strictly a local basis. Systems of this type are referred to as systems of "distributed intelligence."

SOFTWARE FOR REAL-TIME SYSTEMS

The software required in a real-time system is of a much higher level of complexity than that required in conventional systems. This is true simply because the number of functions which must be performed by the software is much greater in a real-time system. A partial list of some of these functions includes: controlling input and output over a number of communication lines and to and from a number of terminals; controlling random access to data files; maintaining waiting lists, or queues, of input entries awaiting processing; administering a system of processing priorities and handling program interrupts; interfacing with other computers in a multicomputer system; responding to malfunctions in any of several components of the system; controlling the allocation of computer memory; and editing and validation of input data and control of errors.

A distinction is generally made between three different kinds of programs in a real-time system. These are (1) supervisory or executive programs, (2) operational or application programs, and (3) support programs. Supervisory programs schedule and control the overall operation of the system, performing all of the functions listed in the above paragraph. A supervisory program may be looked upon simply as a more complex version of an operating system. Operational programs are those which accomplish the actual processing of transactions, performing such functions as updating files and preparing responses to inquiries.

Support programs include such things as debugging aids, testing routines, compilers, and aids to systems design and conversion.

The accountant is interested in the software in a real-time system in several respects. First, he is concerned with the cost of software development, which could be a significant factor in the feasibility of a system. Second, he is concerned with the design of the operational programs, most specifically those which will be applied to the accounting function. Finally, the accountant is concerned that all programs provide the degree of internal control necessary to the system. Three major internal control considerations in a real-time system are data reliability, security, and provision for an audit trail.

With respect to data reliability, one of the accountant's primary control tools, the principle of batching, is lost in a real-time system because transactions are processed individually rather than in batches. This tool must be replaced by a more elaborate system of validating input data at the point of entry into the system. Special programs or subroutines which test the reasonableness and validity of input data must be present in the system. These programs should be designed to request reentry of invalid data, and perhaps to request verification of the accuracy of all critical data. One aspect of a real-time system which is useful for control purposes is that data verification is done by the person in the system who is in the best position to verify source data accuracy – the operator who originates the source data.

One of the major problems of security in a real-time system is the prevention of unauthorized access to the system. In a conventional system, most or all of the data processing equipment is concentrated at a single physical location, so that control efforts can be focused there. In a real-time system, which has many terminals at several remote locations, the problem of unauthorized access is greatly magnified. The most common approach to this problem is to assign each person authorized to use the system a code number that is checked by the system software prior to allowing a user to have access to the system.

The problem of maintaining an audit trail is also greatly magnified in a real-time system. It is possible for a real-time system to be designed so that a transaction could be entered into the system without generating any documentary evidence of the transaction. Teletype terminals produce a paper copy of all activity, and some CRT terminals are also capable of producing a paper copy, which may be a useful form of documentary evidence. Of greater usefulness to the control and audit of real-time systems is the generation by the computer itself of a record of every transaction entered into the system, which is called a *transaction log*. This log identifies the date and time of the entry, the terminal location and user code number, and all relevant data concerning the transaction itself. Generation of this log is one of the functions of the operational programs in a real-time system. Generally the log is initially stored on a random access file, to be written onto tape and/or printed out subsequently at periodic intervals.

REAL-TIME BUSINESS AND ACCOUNTING SYSTEMS

Though real-time systems are generally more costly and complex than conventional data processing systems, their utilization has increased sharply in recent years, which reflects their high potential as a profitable tool of management. Realization of this potential has thus far been primarily limited to the area of control of operations, with benefits being generated from increased efficiency in the logistics function and from improvements in levels of customer service. There remains some controversy over the potential of real-time systems as tools of top management. This section will review the major issues in this controversy and then describe some existing applications of real-time systems in the control of business operations.

Total Information Systems for Management

Much has been written about the utilization of real-time systems by top management. One important concept is that of the *total information system.* The primary characteristic of such a system is that all of the information necessary to manage an organization is collected, processed, and made available at a single central location. All top level executives in the organization have access to this information through terminals located in their offices. The term *data base* is used to refer to large, centralized and integrated files of information. Integration of the data base implies that the information is organized in a manner which facilitates updating the information and preparing responses to inquiries. For the information system to qualify as "total," the data base must contain and integrate all of the information which is relevant to the management of the organization.

Utilization of such real-time systems by top management is possible in both the planning and control functions. The system would assist the manager in planning by enabling him to test the outcomes of various decision alternatives by using a mathematical model to simulate the actual operation of the company. The quick response of the real-time system would enable the manager to "interact" with the model by performing several experiments in a short time period. The real-time system would assist the manager in control by keeping him informed of the existence of problem situations immediately as they occur, thus reducing the time lag between a deviation from plan and an adjustment.

John Dearden has analyzed carefully the functions of top level managers and the promise of real-time systems, and concludes that the concept of a real-time information system for top management is a "myth."[2] Dearden delineates the primary functions of top management, including management control, strategic planning, personnel planning, and coordination. After examining each function in turn, he reasons that a real-time system would not improve management's performance in any of them. For example, with respect to management

[2] John Dearden, "Myth of Real-Time Management Information," *Harvard Business Review,* Vol. XLIV, No. 3 (May - June, 1966) pp. 123-132.

control, he points out that, "In most instances, when situations deteriorate to the point where immediate action is required, top management knows about it." With respect to the use of computer models in strategic planning, he states that the typical manager would be more inclined to assign such tasks to staff specialists, and that the computer can be used for this purpose without the need for a real-time system. In the functions of personnel planning and coordination, he sees no potential for application of real-time systems.

Dearden agrees with most other authorities that real-time systems can produce benefits when applied to operating management. However, he argues that it is a fallacy to equate the control problems of top management with the control problems of operating management. In a subsequent article, Dearden further attacks the concept of a total information system utilizing a fully integrated data base.[3] While stating that integration is a useful concept on a limited scale, he concludes that total integration is also a "myth" for most organizations.

In the several years since Dearden's papers were published, little has happened to alter his basic conclusions. While applications of real-time systems in operations management continue to grow, the idea of top level managers utilizing computer terminals in their offices to help them manage is still closer to a dream than to reality. This tends to support his contention that change, if it comes, will come gradually, leaving business executives plenty of time to adjust if necessary.

Real-Time Systems for Operations Management

While the potential of real-time systems for controlling the executive management process may still be uncertain, real-time systems are being applied to control a variety of operating processes in many business organizations. With the exception of process control applications which monitor physical processes such as petroleum refining or chemical production, virtually all of the major applications of real-time systems in business involve the collection and utilization of accounting data. The major characteristics of several such applications are described briefly in this section.

Sales Order Processing. This area is one in which many companies may find it possible to gain a significant competitive advantage from using a real-time system which shortens the time between receipt of customer orders and delivery. Such a system would maintain its finished goods inventory file online and would have data terminals distributed throughout its sales territory. Salesmen could call orders in to a regional data collection center at which the terminals are located, or alternatively each salesman might be equipped with a small portable terminal with which he could enter orders directly from the customer's plant or office. If the terminal were a CRT, an invoice format could be displayed for the operator to fill in. The system would access the finished goods

[3] John Dearden, "MIS is a Mirage," *Harvard Business Review,* Vol. L, No. 1 (January - February, 1972) pp. 90-99.

inventory file to confirm the availability and quantity of each item ordered, and this information would be relayed to the customer immediately. The finished goods inventory file would be updated as the orders were placed. All appropriate journal entries would be made immediately in the general ledger and the invoice could be immediately posted to the accounts receivable ledger if those files were online. If inventories were stored in a network of warehouses, a copy of the invoice could be transmitted to a data terminal at the warehouse closest to the point of delivery to initiate shipment.

In addition to speeding up the sales order–delivery cycle, the system described above could also have several other useful features. With the accounts receivable file online, a salesman could answer customer inquiries about the status of the customer's account. The credit checking process could also be accomplished online as part of the order entry process. In addition, a sales analysis master file could be maintained online and updated as orders were placed. This file could be used by marketing executives to provide up-to-date information on sales trends, thus facilitating management control of the sales function. Furthermore, as the finished goods inventory balances of ordered items were updated, the updated balance of each item could be checked to determine if reordering or additional production were necessary to replenish the stock. A more extensive discussion of the use of such a system is provided in Chapter 12.

The hardware configuration required to implement a system of this sort could be any one of the configurations discussed earlier in the chapter. An indication of the nature of the operational programs required for the system is provided by the macroflowchart in Fig. 7.11. It should be noted that most of the steps in the flowchart represent a series of more detailed program steps. In addition to the fact that sales orders are confirmed in real time, the system illustrated here is also significant from the standpoint of the complete integration which is achieved in the accounting function. One entry of data results in the updating of all accounting records affected by the data and initiates the preparation of all documents necessary for processing the transaction.

Transportation and travel reservations. Firms in this industry, notably the airline companies and major motel chains, were among the first to implement real-time systems. Applications involve processing and confirming customer reservations, and are actually quite similar to those involving the processing of sales orders. Data terminals are located at each reservations counter or motel lobby. Online file storage devices contain a record of the availability of services at future dates, such as available seats on airline flights or rooms at all motels in a chain. A customer may request a reservation in person or by phone. The reservation is entered on the data terminal, and if the requested seats, room, or other service is available, the file record is updated and the reservation is immediately confirmed to the customer.

In an airline reservations system, functions which may be performed in addition to maintaining records of seat availability and processing reservations

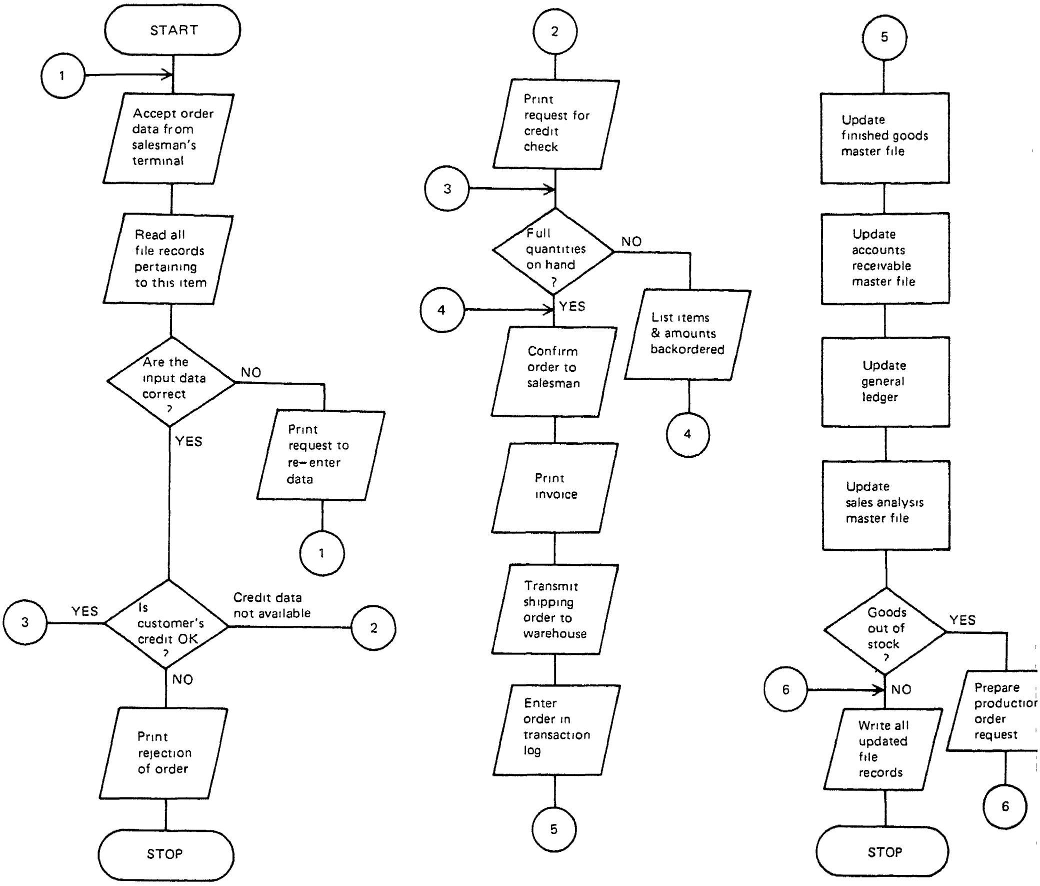


Fig. 7.11 Macroflowchart of a real-time sales order processing system.

include calculation of fares, updating sales and accounts receivable records, responding to customer requests for reconfirmation, and processing passenger check-ins. In a motel room reservations system, functions such as calculation of room charges, guest check-in and check-out, and revenue accounting are generally performed at each local unit rather than by the real-time system.

Banking systems. Savings banks were also among the first institutions to implement real-time systems, and such systems are now common in commercial banks as well. A real-time banking system is used to perform various functions for customers at bank teller windows. The primary function is checking the balance of a customer's account to determine whether it is large enough for a

withdrawal being made by the waiting customer. In addition, deposits and withdrawals may be posted to customer accounts through the system. Hardware requirements for a real-time banking system include a data terminal for each teller window and online file storage to maintain a record of each customer's account.

The real-time banking system makes an up-to-date record of each customer's account available to every teller, even those at branches located at a distance from the main bank. Such systems enable banks to provide faster service to customers, which allows a reduction in the number of tellers required to wait on a given number of customers and reduces the amount of time each customer must wait for service.

Retail sales. Many retail organizations utilize real-time systems to perform credit checking and inventory control functions. Point-of-sale recorders (see Chapter 4) have been specifically designed to serve as data terminals for this type of application. In such applications, a customer's credit standing may be checked at the time a credit transaction is initiated. The customer's account data is then accessed and updated, and a check against a credit limit may be made. If the credit sale is authorized, or if the sale is for cash, the inventory file is accessed and updated for the specific items of merchandise sold. Since this enables an up-to-date record of all inventory items to be maintained, the system can originate inventory reordering as needed.

Because of the expense of point-of-sale recorders or other data terminals, many retail organizations utilize real-time systems in which a centralized data terminal or group of terminals serves a number of retail counters or outlets. For example, in a large retail store with several branches, there might be one or more terminals centrally located at each branch store. Each sales clerk would dial a terminal operator within his own branch when a need to check credit arose. The terminal operator would then access the central computer system, obtain the necessary credit information, and respond to the sales clerk over the phone. A similar example is furnished by the large oil companies, in which each service station operator may dial a regional center from which terminal operators may make inquiries regarding the status of customer accounts. In most such systems the retail clerk or attendant will not initiate the credit check unless the amount of the sale exceeds a specified sum, such as $20.00.

Manufacturing control systems. A real-time manufacturing control system is used to perform several functions relating to the scheduling and control of work in process. These functions include control of raw materials inventory, purchasing and receiving, scheduling of factory workers, scheduling of machine usage, quality control, control of finished goods inventories, and shipping. Unlike the airline, banking, and other real-time systems, the requirements of users of real-time manufacturing control systems are likely to vary greatly from firm to firm. Generally such systems require online file storage to maintain a current record of all work in process in the factory. Every change in status of a work

in process item is recorded online as it occurs from data terminals located in the factory. For example, each time a worker completes a job, he enters all relevant data pertaining to the job into the system from the terminal.

The functions which may be performed in real time by a manufacturing control system include: verifying the accuracy of data input; assigning workers and machines to jobs in accordance with an optimum schedule which takes into account job priorities, machine availability, and other conditions; responding to inquiries regarding the status of specific work in process items; and preparing purchase requisitions for raw materials whose balances fall below their reorder point. In addition, if it is economical, the cost control function can be performed in real time, with significant cost variances being reported to foremen and to the plant superintendent as they occur.

The real-time manufacturing control system provides several advantages, foremost among which is the increased efficiency which can be achieved in manufacturing operations. Such a system helps to maximize machine utilization, minimize raw materials and work in process inventories, assure fast processing of rush orders, and also enables quick responses to changes in conditions, such as a machine breakdown. A more extensive discussion of these systems is provided in Chapter 14.

REVIEW QUESTIONS

1. Define the following terms:

real-time system	wide-band
dispatching	modulation
simplex system	demodulation
multiplexor	modem
duplex system	data set
multiprocessing system	multidrop lines
program interrupt	transaction log
subvoice grade	total information system
voice grade	data base

2. How short must the response time of a system be in order for the system to qualify as real-time?
3. True or False:
   a) A real-time system is a type of feedback control system.
   b) The central computer in a real-time system cannot be used for any functions other than the real-time application.
4. Distinguish between real-time systems and online systems.
5. What are four general functions which may be performed by a real-time system? Which of these functions by itself is not a form of real-time processing?

6. What are the four general categories of computer hardware required in a real-time system?
7. Describe several features required of the central processor in a real-time system.
8. What are the relative advantages and disadvantages of the following real-time system hardware configurations?
   a) simplex system
   b) simplex system with multiplexor
   c) duplex system
   d) multiprocessing system
9. Describe the primary system characteristics affecting the choice between disk and drum file storage in a real-time system.
10. What are some choices available to the real-time system designer with respect to providing for backup file storage?
11. What are the primary factors affecting the choice between teletypewriters and display terminals in a real-time system?
12. What are the primary advantages and disadvantages of utilizing online data entry in a computer system?
13. With respect to speed of data transmission, communication lines fall into one of three categories. What are these categories and what range of speed does each provide?
14. Describe two basic options offered by the communications companies to data transmission customers with respect to usage of facilities? What are four major factors affecting the choice between these two options?
15. Distinguish between analog and digital signals. What device is used to convert signals from one of these forms to the other?
16. Discuss the relative advantages and disadvantages of using (a) point-to-point lines, (b) multidrop lines, or (c) a multiplexor in configuring a data communications network.
17. What is a system of "distributed intelligence"?
18. List several functions which must be performed by the software in a real-time system.
19. Describe three different categories of programs in a real-time system.
20. Describe three major internal control considerations in the design of real-time software systems.
21. Describe the ways in which a real-time system could be used by top management. What arguments have been made to support the contention that real-time systems are not useful to the top management function?
22. Describe briefly five examples of the use of real-time systems in the control of operating processes in business.

DISCUSSION QUESTIONS

23. Discuss the controversy over whether real-time systems are useful to top management executives in the performance of the management function. Do you feel that it would be worthwhile for each top executive in a large, multidivisional company to have in his office a computer terminal linked to the company's central computer system? Can you conceive of circumstances in which it would definitely be worthwhile, or definitely not be worthwhile?
24. Discuss the relationship, if any, between the concepts of real-time system and source data automation.
25. Describe how a real-time system might be usefully applied within
    a) a university,
    b) a life insurance company,
    c) a hospital, and
    d) a construction company.

PROBLEMS AND CASES

26. The Widget Manufacturing Company is planning to install a data terminal at one of its regional sales offices which will be online to the company's computer center. One decision which must be made is whether a private line should be leased or the dial-up service should be used.

    The monthly cost of a leased line would be $1,556. The charge for a long-distance call is $2.60 for the first three minutes and $0.70 for each minute thereafter. It is assumed that the entering of a transaction over the terminal will average five minutes.

    Required:

    a) At what average monthly volume of transactions would the total cost of dial-up equal the monthly cost of the leased line?
    b) Assume that an average volume of 400 transactions is expected. Which alternative would be least expensive and by what amount?
    c) Assume that a good portion of the transactions would be entered in groups of more than one, so that the extra rate for the first three minutes would be avoided for one-half of all transactions if dial-up service were used. How would this affect your answer to part (b)?

27. The Zion Company utilizes a real-time computer system for inventory control. Leased voice-grade data communication lines connect the main warehouse and computer center in Chicago directly with warehouses in Cleveland, Cincinnati, Detroit, and Pittsburgh. Monthly cost rates for these lines are as follows:

Mileage:	0–50	51–200	over 200
Rate/mile:	$3.00	$2.00	$1.50

Distances from Chicago to the other four cities are as follows:

From Chicago to:	Cleveland	Cincinnati	Detroit	Pittsburgh
Distance in miles:	350	302	298	472

The company is considering obtaining a multiplexor to be installed in its Cleveland warehouse. The voice-grade lines from Chicago to Cincinnati, Detroit, and Pittsburgh would then be replaced by leased voice-grade lines from Cleveland to Cincinnati, Detroit, and Pittsburgh. Distances from Cleveland to those cities are as follows:

From Cleveland to:	Cincinnati	Detroit	Pittsburgh
Distance in miles:	238	172	128

Required:

Assume that the multiplexor and related equipment rent for $600 per month. Calculate the amount that the Zion Company would save per month by obtaining the multiplexor.

28. The First State Bank of Los Angeles is designing a real-time system for maintaining its customer accounts and processing inquiries from teller windows. Three files which will be maintained online are: (1) individual checking accounts, (2) individual savings accounts, and (3) institutional checking accounts. The sizes of these three files are 20 million bytes, 6 million bytes, and 8 million bytes, respectively. The frequency of file reference will be very high for the individual checking and savings accounts, but relatively low for the institutional accounts. A very fast response time is desired for all files.

    Systems analysts for the bank are considering either the use of disk file storage for the three files, or drum storage for one of the files and disk for the other two. Rental charges and capacities for representative devices are provided below:

	Monthly rental per unit	Storage capacity per unit
Disk storage unit	$ 570	7.25 million bytes
Disk control unit*	525	
Drum storage unit	2,500	3.9 million bytes
Drum control unit**	400	

* up to 8 disk storage units may be attached to each control unit.

** one or two drum storage units may be attached to each control unit.

Required:

a) Which one of the three files would be the best candidate for use of drum storage? Explain.

b) Determine the total file storage cost if all files are maintained on disk storage.
c) Determine the total file storage cost if the individual savings account file is maintained on drum and the other two are maintained on disk.

29. All other things being equal, explain the effect of each of the following factors on the choice between a teleprinter and a CRT display terminal for a given real-time application.
    a) Volume of usage is very high.
    b) Cost minimization is prime objective.
    c) It is essential to have a record of all terminal activity.
    d) Graphic capability is desirable.
    e) Each transaction requires entry of a dozen data elements, and the terminal operators are inexperienced.
    f) System responses are voluminous and operator time is very valuable.
    g) Minimization of machine noise is essential.

30. The Illinois Wholesale Liquor Corporation utilizes a real-time invoicing, inventory, and accounts receivable system. All sales orders are received in a central Sales Order Department, where they are entered into the system by clerks utilizing CRT terminals. The system immediately transmits a shipping order to one of several warehouses, each of which has a teleprinter online to the system to receive these orders. The system also prepares six copies of a customer invoice for each order, and updates accounts receivable and finished goods master files. The firm's Financial Vice President utilizes a CRT terminal in his office for occasional inquiry into the system. Periodic reports generated by the system include an inventory reorder report (daily) and an accounts receivable aging schedule (monthly).

    Prepare a systems flowchart of the system as described.

31. Prepare a macroflowchart of a program for processing airline reservations according to the procedures described below.
    - The program begins processing when a reservations clerk types in a flight number, date, flight class, number of seats requested, etc. from a terminal.
    - The program checks the validity of the flight number for the date specified. If the flight number is not valid, a reentry of data by the clerk is requested.
    - The program checks whether the requested number of seats are available. If they are, it calculates the fare, reduces the seat inventory, prints a confirmation of the reservation over the terminal, and stops.
    - If the seats requested are not available, the program checks whether seats of the alternative flight class are available on the same flight, and if they are it requests approval to reserve those seats from the clerk. If a favorable response is received, it calculates the fare, reduces the seat inventory, and prints a confirmation of the reservation over the terminal, and stops.

- If alternative class seats are not available, or if the customer does not want the alternative class seats, the program prepares a list of alternative flights on the same date as the requested flight, and prints this list together with a request for the clerk to transmit either a termination signal or another reservation request.
- If a termination signal is received, the program stops.
- If a reservation request is received, the program begins the entire process over again by checking whether the requested flight number is valid for the date specified.

32. The Texas Machinery Distributing Company is a wholesaler of a variety of machinery products with headquarters and central warehouse in Houston, and sales offices in Dallas, Waco, Austin, San Antonio, Corpus Christi, Abilene, and Laredo, Texas. The Company has decided to install a real-time system for processing sales orders. The computer center is located in Houston, and one terminal will be located in each sales office.

    A major concern of the company in the design of the real-time system has been the cost of the data communications network. The company is considering four alternative configurations:

    (1) seven subvoice-grade leased lines, one each from Houston to each sales office.
    (2) a voice-grade line from Houston to Austin, and a multiplexor in Austin to service six subvoice-grade leased lines from the other six sales offices.
    (3) dial-up service from each sales office to Houston.
    (4) a voice-grade line from Houston to Austin, and a multiplexor in Austin to service dial-up from the other six sales offices.

    Monthly cost figures obtained from the communications company for subvoice-grade and voice-grade leased lines are as follows:

Subvoice-grade:	mileage 0-100	101-250	over 250
	rate/mile $1.75	$1.23	$0.70
Voice-grade:	mileage 0-25	26-100	over 100
	rate/mile $3.00	$2.10	$1.50

    As an example of how these figures are used to arrive at the monthly charge, a voice-grade leased line of 120 miles would cost $3.00 (25) + $2.10 (75) + $1.50 (20) = $262.50 per month.

    The following table shows the distance in miles from Houston to the seven sales offices, and from Austin to the other six sales offices:

	Waco	Austin	Dallas	San Antonio	Laredo	Corpus Christi	Abilene
Houston	181	164	244	195	312	208	349
Austin	106	–	198	79	233	194	217

The table below shows the cost of a three-minute long-distance call from Houston to the seven sales offices, and from Austin to the other six sales offices.

	Waco	Austin	Dallas	San Antonio	Laredo	Corpus Christi	Abilene
Houston	0.55	0.55	0.66	0.55	0.77	0.66	0.77
Austin	0.55	–	0.55	0.55	0.66	0.55	0.66

It is assumed that each call will consume three minutes or less. The table below shows the expected average monthly volume of calls from each of the seven sales offices:

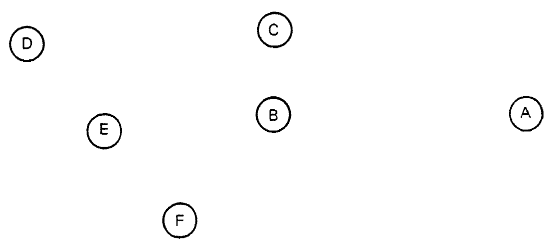
Office:	Waco	Austin	Dallas	San Antonio	Laredo	Corpus Christi	Abilene
Monthly volume	300	600	900	700	200	500	300

If either alternative (2) or (4) is chosen, the multiplexor and related hardware will cost $500.00 per month.

Required:

Determine the total monthly cost of the data communication network under each of the four alternatives.

33. Shown below is a map illustrating the relative relationship of six major plants operated by the Gardiner Manufacturing Company.



Gardiner's management wishes to provide a data communications link between its main computer center at point A and data terminals at the other five locations. The alternative network configurations have been narrowed down to three, which are (1) use multidrop lines, (2) locate a multiplexor at point B, lease a line to connect the multiplexor to the central computer, and lease four lines to connect the other four points to the multiplexor, or (3) same as (2) except use switched lines to connect

points C, D, E, and F to the multiplexor. Additional information is as follows:

- The distances between each point and the other five points are indicated in the following table.

Distance from \ to	A	B	C	D	E	F
A		200	220	370	300	280
B			50	180	100	100
C				160	130	150
D					80	140
E						60
F						

- Rates for leased lines of the grade required are as follows:

Milage	0–50	51–100	101–200	over 200
Rate/mile	\$4.00	\$3.00	\$2.00	\$1.50

- If multidrop lines are used, the additional hardware required leases for \$200 per month.
- If the multiplexor is used, its monthly lease cost is \$400.
- If switched lines are used, the cost per minute for a long-distance hookup between point B and the other four points are as follows:

Point B to:	C	D	E	F
Rate/minute	.15	.20	.18	.18

- The estimated volume of usage in terms of hookup hours per month for locations C, D, E, and F is as follows:

Location	C	D	E	F
Hours/month	40	20	30	20

Required:

Compute the total monthly cost of data communications under each of the three specified alternatives.

PART THREE

SYSTEMS INVESTIGATIONS

Chapter 8

Survey and Analysis of Information Systems

Two factors create the necessity for frequent change in the information systems of business organizations. One is the growth of business organizations themselves in a dynamic society, which produces both new demands for information and greater volumes of data processing. A second factor is the rapid improvement of information technology, which offers a potential competitive advantage to those firms which are among the first to innovate.

The past two decades have seen rapid growth in business organizations generally, and great improvements in information technology. As a result, changes in the information systems of many firms have occurred with some regularity. Because the time required to accomplish a major change, particularly one involving computerization, may range from a few months to two or three years or more, systems change may appear to be more a permanent than a temporary phenomenon for many business organizations.

Because of its importance, the process of systems change is deserving of considerable study. Such study should emphasize those techniques and patterns of change which have proven most successful. Part Three of this book, encompassing Chapters 8 through 11, will focus on the management of systems change. Chapter 8 discusses techniques of and problems relating to the survey and analysis of existing systems for which change is being contemplated. Chapter 9 discusses techniques and problems peculiar to the decision to acquire a computer system for information processing. Chapter 10 covers the process of implementing a major systems change, and Chapter 11 discusses the management and control of computerized information systems.

The description of systems change in Part Three assumes a situation in which major change is contemplated for an existing information system serving an entire organization. Such changes generally involve hardware, as exemplified by a change from a manual to an automated system or from batch processing to online processing capability. However, some major systems changes may involve primarily a software design philosophy, as, for example, a change from separate subsystems to a totally integrated system, or from comprehensive reporting to exception reporting. While the focal point of these

chapters is primarily the large-scale systems change, many of the approaches and techniques discussed are also applicable to changes within smaller subsystems.

Part Three is written primarily from the broad perspective of the systems analyst, rather than from the more limited perspective of the accountant. This is because a major systems change will affect all of the major users of an information system within an organization. Of course the accounting function, as one of the primary users of the information systems, should be vitally interested and involved in the process of systems change. In addition to involvement as a system user, the accountant may contribute his expertise to a systems investigation in the form of both an analysis of cost factors and a concern for the establishment of effective internal control in the system.

THE STRATEGY OF SYSTEMS CHANGE

Since management decisions are based on information, it is axiomatic that the successful management of an organization is related to the effectiveness of its information system. It is therefore important that systems change be carefully planned and directed by management. This section discusses several aspects of a successful strategy of systems change.

The Systems Approach

The systems approach to systems change emphasizes a number of specific approaches and policies relating to the planning of systems investigations. One is an emphasis on viewing problems and alternatives from the standpoint of the entire organization, rather than from the standpoint of any single department or interest group. Another is the requirement of a careful step-by-step approach to each task, which necessitates the thorough exploration of all implications and alternatives at each step in the project. A third useful approach is an emphasis on defining the objectives of the system as a framework for analysis of problems and opportunities.

Still another essential aspect of the systems approach to systems change is the use of the "team approach," in which systems specialists, operating managers, and other groups which are significantly affected by a systems change participate together in a coordinated effort throughout the various stages of the project. Use of the team approach to systems investigation reflects formal recognition of the fact that problems of major importance in an organization cannot be approached from a limited perspective. For example, accountants alone cannot design a reporting system which is to provide useful information to marketing executives. Similarly computer specialists alone cannot be expected to design a computerized data processing system to replace an already operating manual system. Responsibility for such major projects should be assigned to a team whose members represent all of the diverse specializations which are relevant to the problem. Such an approach is not only likely to produce more

effective results, but also will facilitate the acceptance of the results by all parties concerned. Thus an operating manager will feel more favorably disposed toward a system which he helped to develop than toward one which is imposed upon him by what he considers "outside" forces.

In the context of computerized information systems the most critical need for close cooperation arises between operating management and systems specialists. Operating managers often fail to recognize the potential benefits of computerization, whereas systems specialists often fail to understand the complexities of an operating system. If allowed to work in isolation from one another, these two groups may never feel compelled to respect each other's point of view. If obliged to work together on a project, the outcome of which will affect their own personal success, they are more likely to achieve a reconciliation of viewpoints sufficient to enable a working relationship to be established.

Perhaps the most important factor of all in successful planning for systems change is the involvement of top management. Such involvement begins with participation in the process of defining objectives for the information system. Top management must select the members of the project team, taking care to achieve a proper balance of operating managers and systems specialists. Top management must clearly define the responsibilities of the project team and demand from them a report containing a thorough analysis of the merits of all alternatives from the standpoint of the organization as a whole. Members of the project team must understand that they are responsible to top management for the eventual success or failure of the course of action they recommend.

Defining the Objectives of the Information System

The specific objectives of an information system are a function of the objectives of the organization which that system serves. Some authorities have suggested that every organization has a limited number of "key success factors" which must be identified to provide direction for systems planning.[1] By way of illustration, consider an automobile manufacturer, to whom the key success factors are product styling, manufacturing cost control, and an efficient dealer organization, according to Daniel. Identification of key success factors enables the systems planning and development group to focus upon the elements of the information system which are most vital to the success of the organization.

Certain general objectives, important in all information systems, may be identified. A partial list of these would include the following:

1. Usefulness – the system should produce information which is timely and relevant for decision making by management and operating personnel within the organization.

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[1]See, for example, D. Ronald Daniel, "Management Information Crisis," *Harvard Business Review,* September-October, 1961, pp. 111-121 and William M. Zani, "Blueprint for MIS," *Harvard Business Review,* November-December, 1970, pp. 95-100.

2. Economy – all component parts of the system, including reports, controls, machines, etc., should contribute a benefit value at least as great as their cost.
3. Reliability – system output should possess a high degree of accuracy, and the system itself should be capable of operating effectively even while a human component is absent or while a machine component is temporarily inoperative.
4. Customer service – the system should provide courteous and efficient customer service at points of interface with the organization's customers.
5. Capacity – the system should have sufficient capacity to handle periods of peak operation as well as periods of normal activity.
6. Simplicity – the system should be simple enough that its structure and operations can be easily understood and its procedures easily accomplished.
7. Flexibility – the system should be sufficiently flexible to accommodate changes of a reasonable magnitude in the conditions under which it operates or in the requirements imposed upon it by the organization.

Thinking about systems problems in terms of objectives such as these helps to clarify the true nature of such problems. For example, the problem of maintaining adequate internal control must be examined as a trade-off between the objectives of economy and reliability. Similarly the problem of cutting clerical costs must be analyzed in terms of a trade-off between the objective of economy on the one hand and capacity, flexibility, and customer service on the other. Once the objectives which are relevant to a particular problem are specified, a framework is provided for subsequent data collection and analysis. Of course it is impossible for any system to completely satisfy all of these objectives, but the objectives themselves do provide useful guidelines for systems planning.

Assessing the Information Needs of Management

As noted earlier, one of the most important objectives of an information system is to produce useful management information. Unfortunately this objective is often underemphasized in practice. Even when it receives the attention it deserves, it is still perhaps the most difficult of objectives to satisfy. For these reasons the subject will receive special attention here.

If an information system is considered in terms of a cycle of input, processing, and output, it seems logical to establish the required output prior to designing the system for input collection and processing. In practice, however, many factors create pressures which serve to lessen the emphasis given to output in systems design. Input collection is traditionally constrained to data provided as a by-product of transaction processing. Those responsible for the processing itself may be more interested in and knowledgeable about procedures and equipment rather than management decision making. They may interpret volume of output as being synonymous with quality of output. In the face of such pres-

sures, positive steps must be taken to assure that systems analysis and design give proper consideration to the information needs of management.

A proper analytical approach to assessing management's information needs should begin with an identification of the decisions for which management requires information. A distinction should be made at this point between top management and operating management. The scope of an operating manager's authority is limited to a particular department or area, and his function can usually be reasonably well defined. The decisions for which he is responsible are known, and the data and decision rules for making these decisions are often clearly specified, perhaps in an operating manual. If his needs for information are not being completely satisfied, the operating manager can probably identify with reasonable precision what additional information he requires. In most cases the information he needs can probably be generated internally. In short, specifying the information requirements of operating management does not usually present major problems.

On the other hand, a top level manager's authority relates to the entire firm. The decisions for which he is responsible are not always clear. His function is defined only in vague terms such as establishing policies, planning and control, or making a profit. His needs for information are not limited to that which can be easily generated internally. If he is asked to specify his information needs, he may not be very successful in doing so. Thus a precise identification of the decision responsibilities and information requirements of top management is not a simple task. Perhaps the best available framework for approaching this task is the conceptualization of the top management function in terms of planning and control. Each of these functions will now be examined in turn.

The planning function is oriented toward environmental factors – the market, the economy, competitors, resource availability, and so forth. The budget, a formal planning statement, is based upon forecasts of sales. Planning decisions include setting prices, devising market strategies, and allocating resources among various research, product development, promotional, and other projects. Thus the type of information required for planning purposes is primarily external. It is not the kind of information that is generated more or less automatically as a by-product of transaction processing. To assure the proper collection and consideration of this type of information, it is necessary to assign formal responsibility for the task. This need is a major reason behind the recent trend toward the appointment of a planning executive at the top management level.

One approach which the information system designer can take to establish a formal system for collecting and utilizing planning information is to design a management planning model.[2] Although such models take many

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[2] See, for example, George W. Gershefski, "Building a Corporate Financial Model," *Harvard Business Review,* July–August, 1969, pp. 61–72; John Dyment, "Financial Planning with a Computer," *Financial Executive,* April, 1970; pp. 34–46; and Leroy J. Pryor, "Simulation: Budgeting for a 'What If ...?'," *Journal of Accountancy,* November, 1970, pp. 59-63.

forms, their general purpose is to enable management to experiment with various decisions or policies, while the model simulates the operation of the firm and its interaction with the environment to predict the outcome of each decision or policy in terms of profits, market share, and other objectives. The construction of such a model requires a considerable investment of time and resources. However, if it is done properly, it can greatly clarify management's planning information requirements (as well as establish a structure for collecting information to meet those requirements) and provide a tool for efficient utilization of the information in decision making.

On the other side of the coin, the control function involves the evaluation of results of operations relative to the plan. Control decisions thus involve a comparison between planned results and actual results, an interpretation of the significance of deviations from the plan, and the choice of a course of action which will further encourage favorable deviations from plan and avert unfavorable deviations. The information required for control decisions includes the output of the planning process, such as the operating budget, and corresponding reports on the results of operations, such as financial statements and performance reports. In addition to information in monetary form, some control decisions also require nonmonetary information, such as measures of efficiency of production or effectiveness of marketing programs. Whereas monetary information for control decisions is usually provided by the accounting information system in most progressive business organizations, nonmonetary control information is frequently not available, which presents a major challenge to systems designers.

Because the control function is not nearly as unstructured as the planning function, it may be possible to approach the problem of designing a system to produce nonmonetary control information by first isolating the decision responsibilities of each executive in the area of control. Then the characteristics of each decision must be identified – how often is it made, what information is required to make it, and what decision rules, if any, are used in making it. Primary attention should be given to the task of determining what information is desired, but not provided by, the system. Because the control function is internally oriented, much of the needed information may be available internally. If so, the primary systems design problems will involve measuring, processing, and reporting the information in a form useful to the receiver.

The accounting information system, in view of its traditional role as a supplier of information to management, should be vitally involved in the process of assessing management's information needs. However, accounting systems have often been criticized, both in the literature and in practice, for failing to prepare information which is adequate to satisfy the information needs of management. A common criticism is that accountants perceive information solely in terms of what can be generated as a by-product of transaction processing and financial statement preparation. Although transaction processing is an important source of information, accountants should broaden their perspective and include all sources of financial information which is useful to management.

Another common criticism of accountants is that they are exclusively concerned with reporting monetary information. The transaction data base for which the accounting system is responsible contains much nonmonetary data, but the accounting system often fails to exploit this available data source. For example, accounting systems often restrict inventory reporting to dollar information only, whereas unit inventory information would probably be much more useful to operating personnel. More extensive involvement of accountants in the assessment of information needs could serve to reduce the problems underlying these criticisms of accounting systems.

With respect to the planning function, the role of the accounting information system in the assessment of management's information needs is less clear than it is with respect to the control function. Traditionally the marketing, economics, and engineering functions have played central roles in the generation of planning data. However, the accounting system is directly involved in the processing of this data through the medium of budgets. Furthermore, much of the impetus in the area of management planning models has come from accounting. Thus accountants should also play a central role in the determination of planning information needs in an organization.

SYSTEMS SURVEY

Once the most important objectives of the information system have been pinpointed and the information needs of the various levels of management have been identified, the process of gathering information concerning the current state of the system begins. This process will be referred to as systems survey. Its purpose is to obtain an accurate perspective on the existing system in order that areas of weakness which are causing problems can be identified and that changes necessary to correct such weaknesses and resolve all major problems can begin to be conceived.

Human Factors in Systems Survey

One of the primary sources of information to the systems analyst regarding the operation of an existing system is the people who are involved in operating it and utilizing its output. Thus the systems analyst needs to work closely with the people in a system during the survey phase of a systems investigation. Although this may occasionally involve merely recording his observations, it will much more frequently require the systems analyst to conduct interviews with operating people and managers. To fulfill this aspect of his role effectively, the systems analyst needs to be sensitive to the feelings of people generally and aware of some of the more common human problems which arise in an organization during a systems investigation.

The presence in their midst of a systems specialist, who is a staff person or perhaps even an outsider,.can be disconcerting to operating managers and personnel. The fact of his sudden interest in their work is an indication that a

possible change may be under consideration. His requests for information and interviews are disruptive of the normal routine. In such a situation, the fear of uncertainty which is natural in people can generate mistrust and rumors, and perhaps be damaging to morale and efficiency.

Proper planning of systems investigations recognizes that people do not fear change by itself, but do have a fear of the uncertainty that accompanies change. Such uncertainty should be minimized to the extent that it is possible to do so. This can be accomplished by a policy of open communication with employees for the purpose of clarifying the intentions of the company regarding the investigation in progress. Generally the objective of such a policy should be to develop an attitude in employees such that they identify *with* the company and the system in its efforts toward improvement, as opposed to an attitude which perceives the company and the system as something having goals and plans which are separate from or even opposed to those of employees. Several more specific methods of accomplishing this objective are briefly discussed here.

As a first step in the survey phase of a systems investigation, the analyst should arrange to hold meetings with operating managers whose departments may be affected by the study. He should make clear the scope of the study — whether a major change, such as automation, is being contemplated, or whether modifications of lesser magnitudes are the goal. The analyst should discuss the reasons for the study in positive terms, stressing the contribution that each department makes to the organization and the desire of company management to provide them with the best possible support. Stating objectives in negative terms, such as mentioning a need to correct existing problems, raise efficiency, or cut costs, should be avoided. The analyst should emphasize his own need for the assistance of operating managers and their personnel in the project and encourage them to participate by offering their ideas and suggestions.

In cases where the change being considered is very broad in scope, as in the case of a study to assess the feasibility of computerizing an existing manual or semiautomated system, the systems analyst must anticipate that many operating managers and their subordinates will fear the loss of their jobs, their seniority, or their status. Many personnel policies may be used to soften the impact of such major changes, and the analyst should make sure that management communicates its intentions in this regard to its employees. For example, existing employees may be given the first chance at new positions which become available and encouraged to test for such positions. Training programs may be offered by the company or by the firm from which equipment is being acquired. Communication with employees on this subject should stress the increased opportunities for advancement and more rewarding work which will result from the change.

In most medium-to-large-sized organizations, a policy of relocation of displaced employees in jobs of equal pay and status will be feasible. If hiring rates are temporarily reduced, the normal attrition of employees will enable

such displaced personnel to be assimilated into the regular work force within a year or two. In the case of employees who are within a few years of retirement, it may be possible to arrange for an early retirement. In the case of persons whose employment is terminated, severance pay and assistance in obtaining new positions may be provided. Such policies may be expensive, but the decline in morale caused by the lack of such policies could be even more expensive. In any event, all such policies which will be adopted should be communicated to employees, and the full backing and genuine interest of top management should be made clear.

The planning of a systems investigation should also take into account human factors and attitudes with respect to the top management personnel who are closely involved with the study. One factor of primary importance is the willingness of top management to involve itself in monitoring and providing direction for the systems effort. Of equal importance is the concern of top management in maintaining an atmosphere of good human relations and high morale among employees. Also important is a willingness to adjust to changes in organizational relationships and to become familiar with a new pattern of systemization or a completely new technology. To the extent that each of these factors is present in top management, the process of systems change will be much easier to plan for and carry out.

Other Activities in Systems Survey

In addition to information and suggestions obtained from personnel during a systems survey, much information must be acquired or developed from other sources. One such source will be the documentation of a system. Ideally this should contain complete procedures manuals, job descriptions, flowcharts of all processing operations, operating instructions for all equipment, copies of all documents and reports, and so forth. If the system documentation is not available or not complete, the analyst will find it useful to develop it himself, at least in rough form.

Measures relating to the volume of processing are also important to the systems analyst at this stage. For each processing operation, an estimate of average volume should be obtained, as well as an assessment of the variability of volume, particularly with regard to the frequency and duration of periods of peak volume. Trends in the average and peak volume are also significant as indicators of future capacity requirements. Sometimes a relationship between processing volume and sales volume can be developed and used to generate predictions of future processing volume on the basis of available estimates of future sales volume. In addition to measures of volume, the analyst should obtain data on the percentage utilization of individual items of equipment and on the time required for, and time actually spent by, each employee in performing the tasks of which his job consists. All of these data are useful to the analyst in assessing the degree to which available processing capacity is

being utilized by the current system, and the extent to which the capacity of the current system is sufficient to meet future processing requirements.

Work Measurement

One well-developed set of techniques for obtaining and making use of data on the time required for employees to perform their jobs goes by the title of *work measurement*. This set of techniques is primarily applicable to jobs consisting of routine, repetitive clerical activities such as filing, typing, calculating, posting, sorting, and so forth, rather than to less structured functions such as management or creative work. To some extent, the applicability of work measurement techniques has declined in recent years, due both to a tendency toward relaxation of rigid work standards as part of an increased emphasis on employee morale, and to the increasing degree of automation of routine clerical functions. However, the approach can potentially be very useful in some cases, and as such is worthy of at least a brief general description here.

A work measurement study begins by breaking down the routine functions in the department or process under investigation into the set of distinct tasks or activities of which each consists. A time and motion study of each task is made to obtain a measure of the average time for performance of a single unit of each activity, such as the typing of a single purchase order or posting of transactions to a single account. Time and motion study involves observation of the performance of a task by a skilled employee and maintenance of a record of time spent. Observations should be taken at several different times to obtain a sample of observations which is representative of the various conditions under which the task is performed.

Once a measure of average time per unit of activity is obtained, it should be adjusted for work delays, such as interruptions, errors, machine breakdowns, and satisfaction of personal needs for rest or other relief. This adjustment is usually made in the form of a percentage of work time. For example, if ten percent of total work time is considered an adequate adjustment for work delays, then the average time per unit of activity is increased by ten percent to give an adjusted average time.

The next step is to multiply the adjusted average time per unit of activity by the average volume of units of activity in a processing cycle, which may be a day, week, or month depending upon the operation. This gives the total time required for each separate activity during the processing cycle. Once this is done for all activities in the process or operation, the sum of the total times for all activities provides a measure of the total work time required in the operation during a processing cycle. At the same time, a measure of the total time spent on the job by all employees in the operation during a processing cycle can be determined. Dividing the total time required by the total

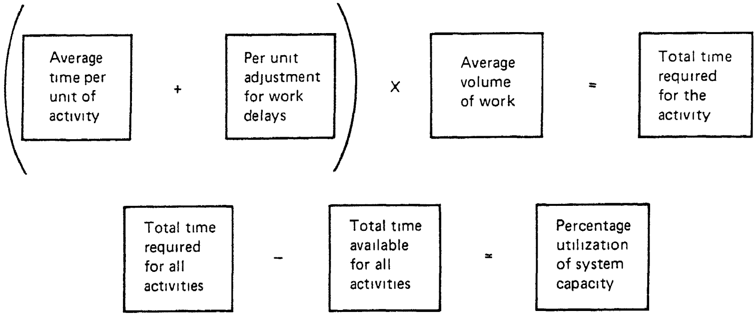

Fig. 8.1 Work measurement calculations.

available working time provides a rough measure of the percentage utilization of available capacity in the operation.[3] (See Fig. 8.1.)

A work measurement study potentially can contribute a great deal toward accomplishing the objectives of a systems investigation. It may provide a basis for resolving the major problems which initiated the study by utilizing the available capacity of the current system rather than expanding that capacity, perhaps needlessly, through increased hiring or mechanization. It enables a judgment to be made of the extent to which the current system can accommodate expected increases in the volume of processing. As will be discussed in the next section, it provides a basis for a more equitable and efficient redistribution of work in an operation, which may be accompanied by the elimination of some jobs at a considerable cost saving. Finally, after a work measurement study has been completed, it is quite useful to adopt a permanent program of maintaining and updating work measurement data to provide standards for evaluating the performance of clerical employees.

SYSTEMS ANALYSIS AND SYNTHESIS

Upon completion of the survey effort, a systems investigation moves into a period of analysis and synthesis. While the term analysis is used in a general sense to refer to the entire process of systems investigation, it is also used in a more specific sense to refer to the study of the information obtained in a systems survey for the purpose of finding weaknesses and conceiving possible alternative solutions. Synthesis refers to the development of recommendations for a program of corrective action. In reality, analysis and synthesis are so closely related

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[3]For a more detailed discussion of the application of work measurement methods, see Frank M. Rachel and Donald L. Caruth "Work Measurement: A Valuable Tool for Management," *Management Services*, January-February, 1969, pp. 23-24; Harvey E. Schatz "The Uses of Work Measurement," *Management Services*, November-December, 1969, pp. 15-29; and Donald S. Anderson, "Supervisors as Work Measurement Analysts," *Management Services*, January-February, 1971, pp. 20-26.

that a great deal of overlap between them exists. Similarly, some overlap exists between survey and analysis.

At the beginning of the period of analysis, the systems analyst has, on the one hand, a description of the information needs of management which the current system is not satisfying, as well as any other significant problems in the existing system. On the other hand, he has a complete description of how the current system operates. Using these as the basis for his analysis, he must determine what weaknesses are present in the existing system which causes each of the indicated problems. Then he must decide how each of the weaknesses can be corrected in such a way that the problems are resolved and the needs for information are satisfied. In some cases, the main question will be whether the existing system can simply be modified to correct its weaknesses, or whether it must be completely replaced by a newly developed system based upon a higher level of mechanization.

Some General Approaches to Systems Analysis

The direction taken in the analysis of information gathered during a systems survey will vary with the specific characteristics of the system being studied. However, certain general approaches and techniques commonly used during this phase may be identified. A few of these are discussed here.

Focus on problems. Often the description of a systems problem will be suggestive both of the weaknesses which cause the problem and the corrective measures needed to resolve the problem. For example, a problem described as "lack of reliability of output" in a data processing system suggests a lack of certain internal check procedures, the initiation of which might well resolve the problem. Similarly, a problem of "lack of information by which to evaluate the performance of sales clerks" indicates that the identity of the salesman is probably not being recorded on input documents at the point of sale. This suggests the solution of revising the design of sales documents and instituting a procedure whereby all sales clerks are required to enter their name or an identifying number on the sales document at the time of the sale. Some additional processing steps would also be required, including sorting all sales slips by sales clerk and accumulating a total of the number of sales and the total dollar amount of sales for each.

In other cases, however, the solution of a systems problem will be anything but obvious from its description. For example, a problem of "lack of current information on parts inventory balances" suggests the possible inadequacy of the entire materials inventory data processing system. Data collection procedures, documents, files, reports, processing methods and use of equipment should all be reviewed to assess whether a correction of existing weaknesses will resolve the problem, or whether it will not be possible to remedy the situation without automating the system. Furthermore, the scope of the problem is such that the benefits of resolving it will have to be carefully weighed against the cost of doing so. It is probably safe to say that most systems problems possess at

least this degree of difficulty, perhaps because the simple ones have already been solved.

Inquiry of personnel. Operating personnel, including the managers of operating departments, are usually very much involved in the processing of data within an information system, and in the utilization of the information output of the system. Therefore, some useful initial ideas with respect to the possible solution of a systems problem may be obtained by posing the problem to the operating personnel who are involved in the process under study. They may be well aware of the existence of the problem and perhaps have considered methods of resolving it. Their experience and familiarity with the operation enable them to provide valuable opinions regarding the feasibility of alternative possible solutions suggested by the analyst.

While providing a useful framework for initial study of a problem, the opinions and suggestions of operating personnel should not be blindly accepted by the systems analyst. Operating personnel can be expected to have a somewhat biased view of the situation. Viewing conditions from a system-wide perspective, the systems analyst is paid to make an objective analysis of systems problems and to bring his expertise to bear upon their resolution.

Use of checklists. Another common analysis technique is the use of checklists or questionnaires to provide a rough measure of the adequacy of a system. Such checklists generally consist of a comprehensive list of questions concerning various aspects of a system's operation. To each question is applied a weighting factor which reflects the importance to the system of a favorable response to the question. Hence the checklist can be used to derive a "score" representing an evaluation of the manner in which the system is operated.[4] This approach also facilitates the isolation of problem areas within a system by the analyst.

Review of the content and design of documents and reports. Another useful technique in the analysis of information systems is to review the content and design of documents and reports. If a problem of lack of information exists at some point in the system, it could be that data from which to generate that information is not being collected, or perhaps, once collected, is not being processed properly or completely. If the problem is one of failure to collect the necessary data, the need for redesign of input documents and procedures for recording input data is indicated. A review of documents and reports and the related data collection and processing procedures may also provide useful insights on other types of problems. For example, it may be that some data collection and processing steps are being duplicated, in which case a consolidation of documents or reports, or an integration of processing procedures might pro-

[4]For an example of a checklist used to evaluate a computerized information system, see William C. Ramsgard, "Evaluate Your Computer Installation." *Management Services*, January-February, 1971, pp. 37-41. For an example of an internal control questionnaire relating primarily to a manual system, see James B. Bower, Robert E. Schlosser, and Charles T. Zlatkovich, *Financial Information Systems Theory and Practice* (Boston: Allyn and Bacon, Inc., 1969), pp. 589-618.

duce a cost savings. Similarly, a lack of control might be corrected by instituting a change in the procedures for data collection or processing, or perhaps by the prenumbering of a document.

Document flowcharting. The preparation of document flowcharts is another useful means of analyzing an information system. A document flowchart generally illustrates the flow of documents relating to a particular transaction through an organization. It provides the analyst with a broad view of the formal communications network in an organization. The usefulness of this tool to systems analysis justifies presenting a description and giving an illustration of a procedure for preparing document flowcharts.

Information obtained in the survey phase is the basis for preparation of a document flowchart. The analyst must begin by determining the departments, persons, and outside parties involved in the operation or transaction being analyzed. All of the relevant documents and other significant forms of communication which are part of the process must be established. The place of origination of each document, its distribution, the purposes for which it is used, and its ultimate disposition should be determined.

As with other types of flowcharts, document flowcharts use a set of symbols with specialized meanings. However, there is very little standardization of document flowcharting symbols and their meanings. Figure 8.2 illustrates a set of symbols which have fairly widespread usage in document flowcharting. Note the equivalence of several of these symbols to those used in systems flowcharting (see Fig. 5.23). These symbols will be used throughout this book.

The first step in drafting the document flowchart is to segment a blank page into columns by means of vertical lines. One column must be reserved for each entity involved in the process, including departments, persons, outside parties, and so forth. Each column is labeled at the top with the name of its respective entity. The origination of each document on a chart is done by the department or entity within which the document's flow begins. The name of each document is inscribed within the document symbol. The final disposition of a document, either by filing or by other means, is done in the department in which its flow terminates.

The document flowchart is generally assumed to represent a batch mode of processing. Thus each document shown on a chart represents a batch of like documents. Several copies of a given document might be prepared, in which case each copy is numbered on the flowchart to facilitate tracing the subsequent flow of each separate copy. To a limited extent, the use made of documents in various departments can be described in a few words on the flowchart. However, a more extensive description of the procedures and controls present in the system should be prepared separately as part of the documentation supporting the flowchart. A copy of each document shown on the flowchart should also be included in this supporting documentation.

As an illustration of how a document flowchart of an accounting procedure might be prepared, consider the following description of the processing of

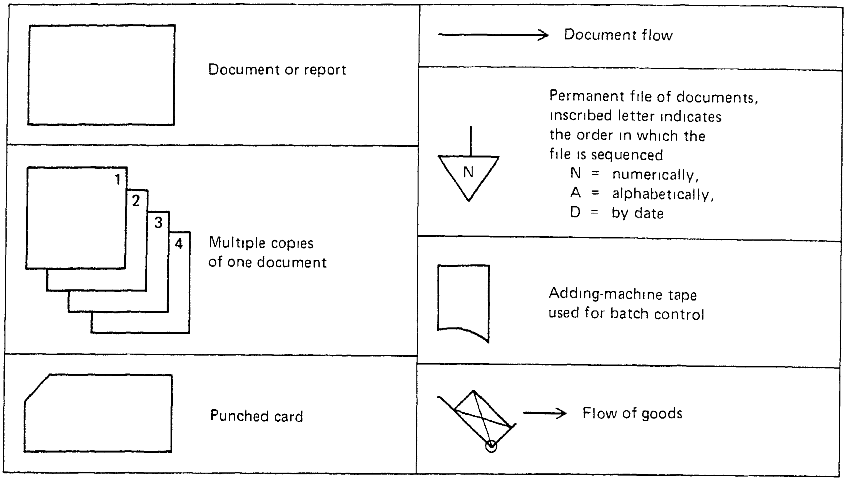


Fig. 8.2 Document flowcharting symbols.

data relating to charges to patients by a hospital. When a patient enters the hospital, an admitting department prepares a record of admittance in four copies. It keeps one copy and sends one each to a medical records section, to the nurses station on the floor where the patient is located, and to the accounts receivable section. In accounts receivable, the admittance records are coded for keypunching by the data processing section and then filed by patient number. Requests for various services for patients originate at the nurses' station and are sent to various hospital departments, such as pharmacy, x-ray, or laboratories. All patient charges are originated in these departments, and a copy of each charge voucher is sent from the charging department to data processing, where they are keypunched. When the patient is released, the nurses station prepares two copies of a notice of release. One is sent to the medical records section where it is filed with the record of admittance. Another is sent to data processing where it is keypunched. Each day the data processing section processes admittance records, patient charges, and release notices against a patient accounts receivable file. One output of this process is a printout of charges to each released patient's account, which is provided to accounts receivable. The accounts receivable department then prepares three copies of a claim report, one of which it keeps, one of which is sent to the patient's insurance company, and one of which is sent to the medical records section to be filed with the record of admittance.

As indicated previously, the process of preparing a document flowchart is simplified if one begins by identifying all departments and other entities, and all documents involved in the process. From the above description, seven entities can be identified as participants in the document flow process. These are: (1) the admitting department; (2) the medical records section; (3) the nurses

station; (4) the accounts receivable department; (5) the data processing section; (6) the service departments, which are lumped into one category because their roles in the document flow process are identical, and (7) the patient's insurance company. Seven documents can also be identified, which are: (1) the record of admittance, (2) the coded admittance record; (3) the request for services for patients; (4) the patient charge voucher, (5) the notice of patient release, (6) the printout of charges to the released patient's account, and (7) the claim report. Once the process is analyzed in this manner, preparation of the document flowchart is relatively straightforward. A complete document flowchart of this process is shown in Fig. 8.3.

By integrating much of the material obtained in the systems survey, the document flowchart provides the analyst with a basic knowledge of the process being charted. Therefore its preparation is often one of the first steps in the analysis stage. It is used in several ways to pinpoint weaknesses in the system. It is particularly useful in analyzing the adequacy of control procedures in a system, such as internal checks and separation of functions. The document flowchart might also reveal inefficiencies present in a system, such as absence of adequate communications flows, or an unnecessary complexity in document flows or procedures responsible for causing wasteful delays. Document flowcharting is also a useful technique in the documentation of a system and in the design phase of a systems investigation.

Review of personnel. Another step in the analysis phase of a systems investigation is a review of the capabilities of personnel in the performance of the functions for which they are responsible. A related step is the assessment of capabilities and aptitudes of personnel with respect to the adjustment necessary to implement and operate a more advanced system. To assist him in this step, the analyst should analyze the task content of each job in question, as well as the requirements for successful performance of the job. To provide a basis for his evaluation, the analyst may observe employees at work, interview the employees and their supervisors, administer special tests, and review formal personnel evaluation records. Ultimately, the analyst must also apply his own judgment to arrive at evaluations which will be useful to his analysis and subsequent effort.

The Synthesis Phase

As indicated previously, synthesis is difficult to separate from analysis, and so it is difficult to cite any approaches to synthesis which are other than extensions of analysis. For example, synthesis would include the development of recommendations relating to the redesign of documents and reports, the improvement of processing procedures, or the revision of document and report flows. This section reviews a few of the processes which can be specifically identified with the synthesis phase.

Work distribution analysis. One synthesis technique is an extension of work measurement referred to as *work distribution analysis.* This technique uses the total time requirements for each activity in a processing cycle, which are deter-

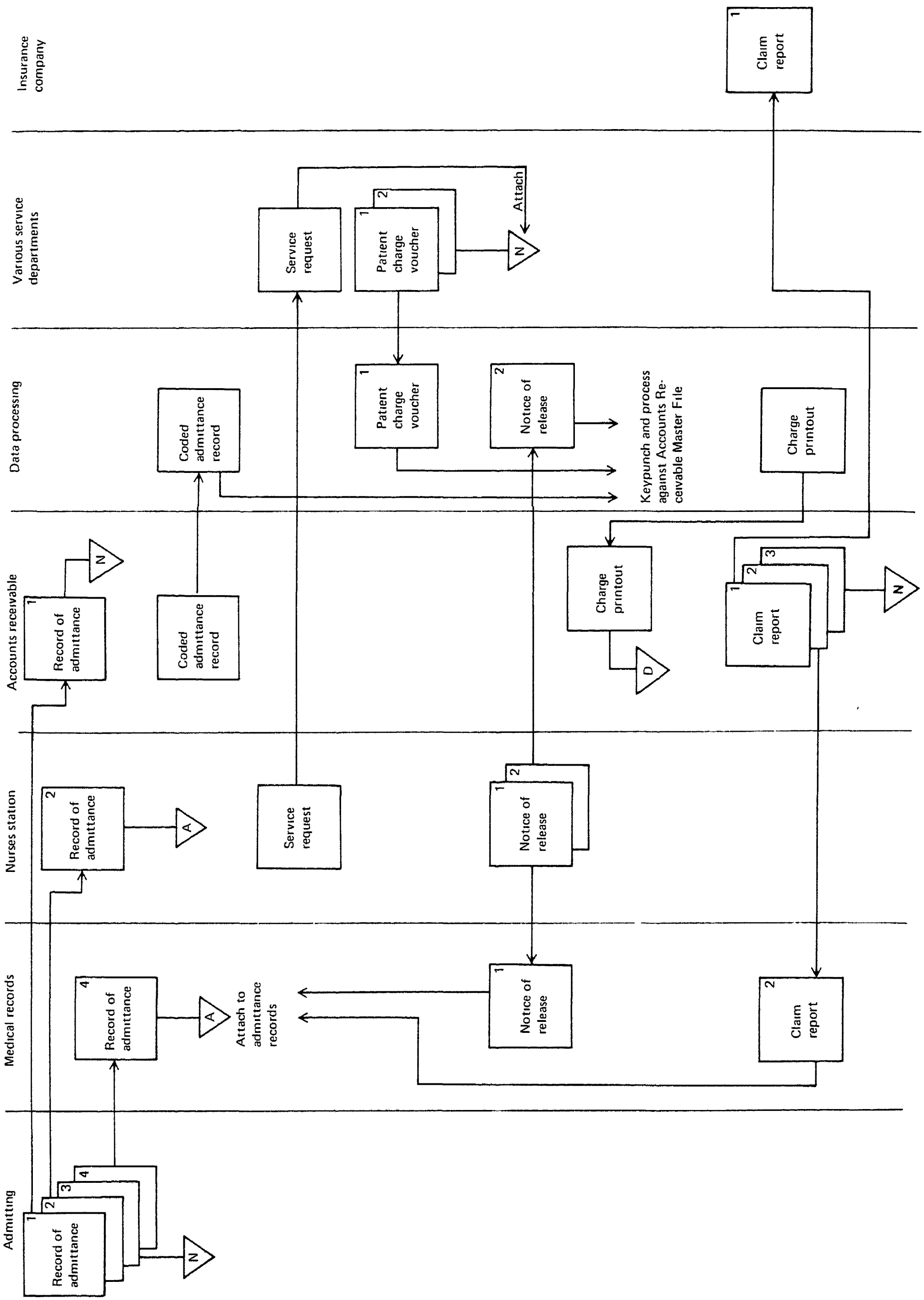


Fig. 8.3 Document flowchart of hospital accounting for patient records.

WORK DISTRIBUTION TABLE					
Accounts Payable Department Activity	Hours per day	Employee			
		Smith	Jones	King	Evans
File purchase order copies	2				2
Match receiving reports with vendor invoices	1				1
Verify accuracy of vendor invoices	6	4	2		
Post receipts to filed purchase orders	5	4			1
Prepare vouchers and checks for payment	8		4	4	
File vouchers payable by due date	1		1		
Batch total day's vouchers to be paid	1		1		
File paid vouchers by vendor	4			4	
Total hours per day	28	8	8	8	4

Fig. 8.4 Sample work distribution table.

mined by work measurement, as a basis for equitable allocation of tasks to employees in an operation. The primary tool is the work distribution table, an example of which is shown in Fig. 8.4. All activities in an operation and the total time each requires are listed line by line on the left side of the table, and each employee's name is listed at the top of a separate column on the right side. Each activity is then allocated to one or more employees in such a way that the total working time for all employees equals the total number of hours for which each is employed per day.

Several aspects of the example in Fig. 8.4 have been oversimplified for illustrative purposes. First, each of the individual activities listed in the table would normally be broken down in much greater detail for purposes of work measurement. However, for purposes of work distribution analysis alone this degree of consolidation is acceptable. Secondly, the work distribution shown in the example provides absolutely no slack time in the system, whereas in practice some allowance would be made for variances in daily volume in order that above average volumes could be handled without a breakdown in the system. In this example, if four hours of slack were to be allowed for in the system, then four additional hours of employee time would have to be added to the system, and the slack time allocated among the employees. Finally the basis for assigning an activity to a particular employee is not indicated. The primary basis for such allocation should be the relative efficiency of each employee in the performance of each task; in this way the total utilization of employee time is minimized. Other considerations include the need to separate the performance of specific tasks for control purposes, or to provide variety in the job assignments to all employees.

Work scheduling. Another factor essential to consider in the development of alternative job assignment plans is the set of scheduling constraints particular to the operation. These include the necessity for completing some tasks before others can begin, or to avoid the simultaneous scheduling of conflicting tasks. Work scheduling involves the assignment of a time dimension to task performance and machine utilization. While important in manual systems, scheduling is an even more critical factor in automated information systems.

Evaluating the feasibility of alternatives. The final necessary step in the synthesis phase is an evaluation of the relative merits of the alternative solutions under consideration. Each alternative should be assessed with respect to the initially stated objectives of the organization and the information system. The pivotal objective is that of economy, to which all other objectives are related. The cost factor may limit the extent to which other objectives can be achieved. Therefore, all cost factors relating to each alternative should be carefully measured, and the benefits of each alternative should be delineated. With respect to measurement of the benefits of the various alternatives, the participation of the users of the information systems is a necessary factor. The information developed from this analysis of alternatives forms the primary basis for management's final choice.

If one or more of the alternatives under consideration involves a computerized system, many additional factors must be taken into account. These factors are covered in Chapter 9.

Presentation of Recommendations

The climax of the period of systems analysis and synthesis is the presentation of recommendations to management. Depending upon the preferences of management and the nature of the problem, such recommendations may be in the form of a delineation of alternatives, or the expression of a preference for a specific solution. In any event, management will be primarily interested in a summary of the major recommendations, the advantages and disadvantages of each, the estimated costs and cost savings generated by the changes, the data used as a basis for the recommendations, and the methods used in collecting the data. In addition to skills in analysis, design, and implementation of information systems, the systems analyst must possess a considerable measure of persuasive power and communicative skill to be successful in this stage of a systems investigation.

REVIEW QUESTIONS

1. What are the primary factors which have made the present era a period of frequent change in the information systems of business organizations?
2. Cite two examples of major systems changes which primarily involve hardware. Cite two examples which primarily involve software design philosophies.

3. Cite three ways in which accountants may contribute to a systems investigation.
4. List several aspects of what might be called the "systems approach" to systems investigations.
5. Describe the philosophy of the team approach to the analysis of information systems.
6. List several ways in which an organization's top management should be involved in the planning and administration of major systems change.
7. What is meant by "key success factors" within a business organization, and what is their importance to systems planning?
8. List several general objectives which are important in the analysis and design of information systems.
9. Why is it logical that the assessment of management's information needs should be the first step in the analysis of information systems?
10. What significant differences exist between the information needs of an operating manager and a top management executive?
11. Briefly describe the planning information requirements of top management. What approach would you suggest to designing an information system to fulfill these requirements?
12. Briefly describe the control information requirements of top management. What approach would you suggest to designing an information system to fulfill top management's needs for (a) monetary control information, and (b) nonmonetary control information?
13. What are some of the implications of your answers to Questions 11 and 12 for the accounting information systems of business organizations?
14. What is systems survey, and what is its purpose?
15. Detail the steps that a systems analyst should take to minimize the possibility of human problems in an information system during the period of systems survey.
16. What attitudes of top management should be taken into consideration by a systems analyst in planning a systems investigation?
17. List several items of system documentation which are an important source of information to the systems analyst during a systems survey.
18. Describe the information which the systems analyst should collect on volume of processing during a systems survey.
19. What is work measurement? For what types of jobs is this technique most appropriate? Give some examples.
20. Describe the steps necessary in a work measurement study to obtain (a) a measure of the total time required for each activity in a system during a

processing cycle, and (b) a measure of the percentage utilization of system capacity.

21. List several ways in which a work measurement study can be useful to a systems investigation.
22. Distinguish between the general and specific meanings of the term systems analysis.
23. List and briefly describe some general approaches to the analysis of weaknesses in an information system.
24. Discuss the advantages and disadvantages of using inquiry of personnel as an analysis technique in a systems investigation.
25. What are two purposes for which a checklist may be used in systems analysis?
26. What weaknesses in an information system may be revealed by a review of the content and design of documents and reports?
27. Identify the symbols used in document flowcharting and indicate the meanings of each.
28. Describe the process of preparing a document flowchart.
29. What weaknesses in an information system may be revealed by an analysis of document flowcharts?
30. What is work distribution analysis? Draw an example of a work distribution table.
31. In work distribution analysis, what criteria may be used for assigning activities to employees?
32. Describe the final step in systems synthesis.
33. Why does a successful systems analyst need to be skilled at communication and persuasion?

DISCUSSION QUESTIONS

34. The discussion of systems analysis in this chapter has been oriented toward a business organization. What significant differences in objectives and approaches would you expect in a system survey and analysis of (a) a public school system, (b) a university, (c) a hospital, (d) an agency of government?
35. Accounting systems are often criticized for perceiving information solely as a by-product of transaction processing, and for overemphasis on monetary data in accounting reports. Are these criticisms justified? Discuss the implication of these criticisms for accounting information systems.

36. Your friend and fellow systems analyst, Joe Doakes, has made the following statement to you:

"The systems analyst does not have to be a psychologist, or be concerned with people problems in his work. His function is to determine the proper facilities, computer or otherwise, for performing the data processing functions of an organization. When this is finished he will then establish job specifications for employees in the system. He can perform these functions with a minimum of contact with people in the organization."

Do you agree with this statement? If not, what line of argument would you use in response to your friend?

37. It was suggested in this chapter that during a systems investigation an organization should make special efforts to ease fears among its employees about potential loss of jobs or seniority. However, it is also felt that one of the primary advantages in the mechanization of a system is the reduction in clerical costs. Are these two concepts inconsistent? What policies could be adopted in an organization during a systems investigation which would be consistent with both concepts?

38. Describe some examples of decisions in systems analysis which involve a trade-off between the objectives of:
    a) economy and usefulness
    b) economy and reliability
    c) economy and customer service
    d) simplicity and usefulness
    e) simplicity and reliability
    f) economy and capacity
    g) economy and flexibility

PROBLEMS AND CASES

39. From the description below of processing of casualty claims by an insurance company, prepare a document flowchart.

The process begins with the receipt by the claims department of a notice of loss from a claimant. The claims department sends the claimant four copies of a proof-of-loss form on which must be detailed the cause, amount, and other aspects of the loss. The claims department also initiates a record of the claim at this time, which it transmits to the data processing section, where it is filed by claim number. The claimant must fill out the proof-of-loss forms in conjunction with an adjustor, who must concur in the estimated amount of loss. The claimant and adjustor both keep a copy of these forms, and send the other two copies to the claims department. The adjustor also submits a separate report at this point. On the basis of this information, the claims department authorizes a payment to the claimant, and forwards a copy of the proof-of-loss form to data processing. The data processing department prepares checks in payment of claims which it mails to the customer, removes paid claims from its file, and prepares a list of disbursements which it transmits to the accounting department.

40. Prepare a document flowchart of the process described in the paragraph below. Where necessary, add narrative explanation to your chart.

    The billing department prepares five copies of each customer invoice, and a batch total of the sale amount on each invoice. Two copies of each invoice in the batch are sent, along with the adding machine tape containing the batch total, to the accounts receivable department. One of these copies is then immediately filed alphabetically by customer name. The other copy is used to post to accounts receivable ledger cards, which are pulled from a numerically sequenced file. As the posting is done, another adding machine tape is prepared in which the ledger balances before and after posting are entered as negative and positive amounts, respectively. At the completion of posting, the two batch total tapes are compared to check the accuracy of the process. Then the customer ledger cards are returned to their original file, and the second invoice copy is filed numerically by customer account number.

41. The Walla Walla Widget Company has completed a time and motion study of its Billing and Accounts Receivable Section. The results of that study in summary form follow:

    Activity and Time Per Unit:
    - Type an invoice in 5 copies from a copy of the sales order — 196 seconds per invoice.
    - Batch total the complete set of invoices for the day — 3 seconds per invoice.
    - Separate copies of each invoice and send copies one and two to the mailroom — 5 seconds per invoice.
    - File one invoice copy alphabetically — 15 seconds per invoice.
    - File one invoice copy numerically — 1 second per invoice.
    - Post debits from another invoice copy to the accounts receivable ledger — 30 seconds per invoice.
    - Post cash receipts to the accounts receivable ledger from remittance advices — 30 seconds per remittance advice.
    - Total the balances of the accounts receivable ledger, and reconcile to sales, cash receipts, and yesterday's total — 1,000 seconds per day.
    - Type customer statements from accounts receivable ledger — 150 seconds per statement.

    Information on daily volume is as follows:
    - Invoices — 200 per day
    - Remittances — 100 per day
    - Customer statements — there are 800 customer accounts. Statements are sent out in a monthly cycle such that about one-twentieth of all customer statements are sent out daily.

    Other information:
    - A 20% allowance should be made for work delays and to provide sufficient slack time in the system to allow for periods of peak volume.

Required:

a) What is the total work time required per day to perform all activities in this operation? Assuming three full-time workers (8 hours per day), what is the percentage utilization of capacity in this system?

b) Suppose the system employs two full-time workers (8 hours per day) and one part-time worker who works exactly the number of hours necessary to complete all work. Prepare a work distribution table showing how the various tasks might be allocated among these employees.

42. Charting, Inc., a new audit client of yours, processes its sales and cash receipts documents in the following manner.[5]

1. Payment on account. The mail is opened each morning by a mail clerk in the sales department. The mail clerk prepares a remittance advice (showing customer and amount paid) if one is not received. The checks and remittance advices are then forwarded to the sales department supervisor who reviews each check and forwards the checks and remittance advices to the accounting department supervisor.

The accounting department supervisor, who also functions as credit manager in approving new credit and all credit limits, reviews all checks for payments on past due accounts and then forwards the checks and remittance advices to the accounts receivable clerk who arranges the advices in alphabetical order. The remittance advices are posted directly to the accounts receivable ledger cards. The checks are endorsed by stamp and totaled. The total is posted to the cash receipts journal. The remittance advices are filed chronologically.

After receiving the cash from the previous day's cash sales, the accounts receivable clerk prepares the daily deposit slip in triplicate. The third copy of the deposit slip is filed by date and the second copy and the original accompany the bank deposit.

2. Sales. Sales clerks prepare sales invoices in triplicate. The original and second copy are presented to the cashier. The third copy is retained by the sales clerk in the sales book. When the sale is for cash, the customer pays the sales clerk who presents the money to the cashier with the invoice copies.

A credit sale is approved by the cashier from an approved credit list after the sales clerk prepares the three-part invoice. After receiving the cash or approving the invoice, the cashier validates the original copy of the

[5] Adopted from Question 5, Auditing Section, American Institute of Certified Public Accountants Examination, November 1969: Copyright © 1969 by the American Institute of Certified Public Accountants and reprinted with permission. The flowcharting symbols provided in the problem differ in some respects from those presented in this chapter. Nevertheless, the problem is illustrative of the usefulness of flowcharting to accounting systems work.

sales invoice and gives it to the customer. At the end of each day the cashier recaps the sales and cash received and forwards the cash and the second copy of the sales invoices to the accounts receivable clerk.

The accounts receivable clerk balances the cash received with cash sales invoices and prepares a daily sales summary. The credit sales invoices are posted to the accounts receivable ledger and then all invoices are sent to the inventory control clerk in the sales department for posting to the inventory control cards. After posting, the inventory control clerk files all invoices numerically. The accounts receivable clerk posts the daily sales summary to the cash receipts journal and sales journal and files the sales summaries by date.

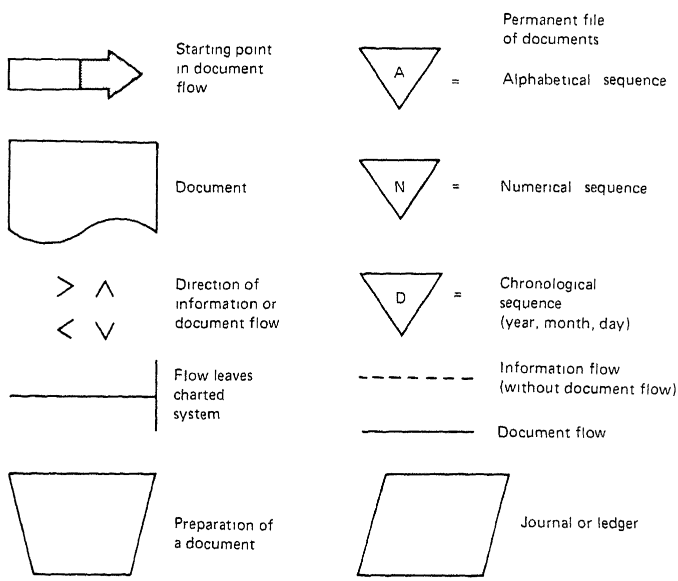
The cash from cash sales is combined with the cash received on account to comprise the daily bank deposit.

3. **Bank deposits.** The bank validates the deposit slip and returns the second copy to the accounting department where it is filed by date by the accounts receivable clerk.

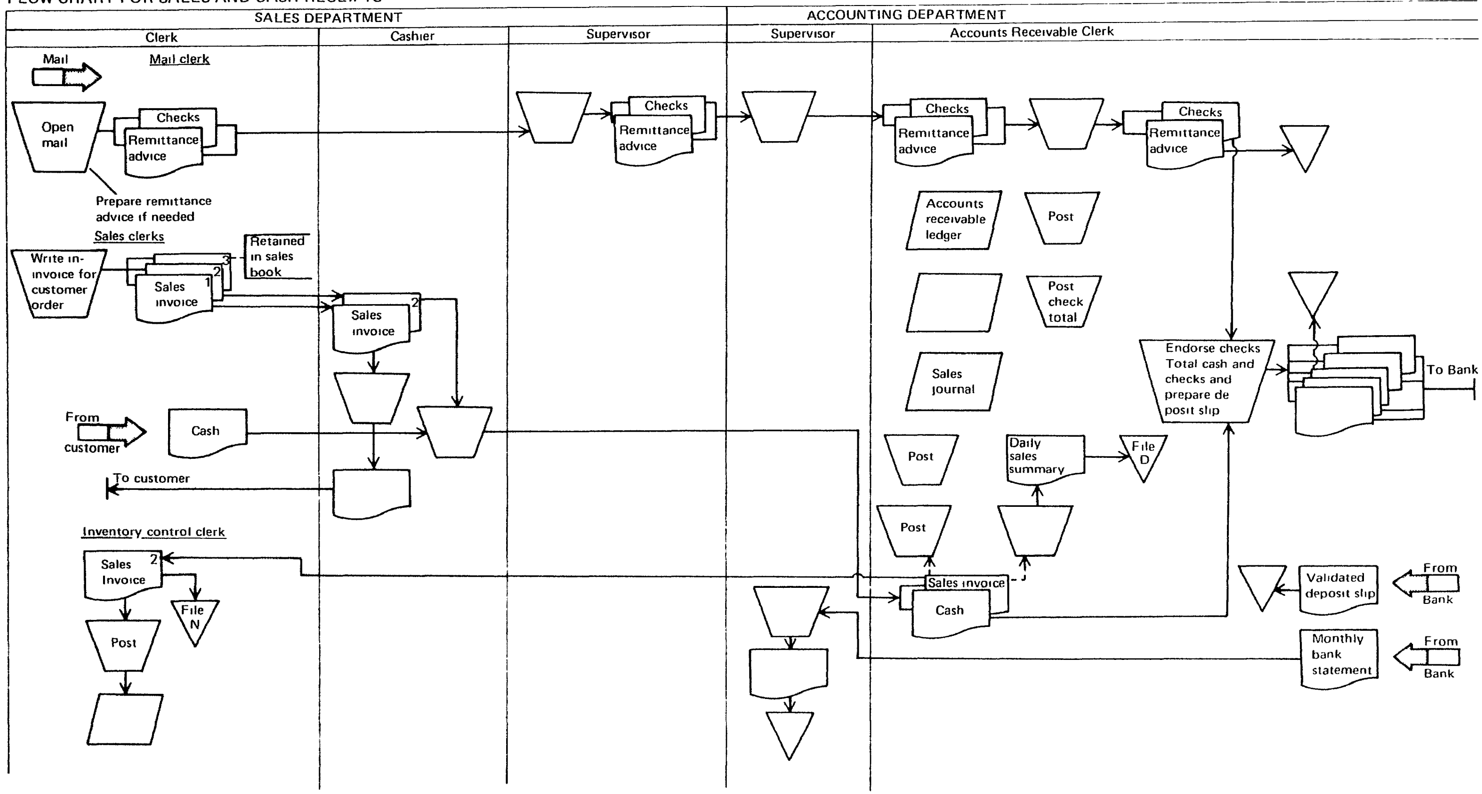
Monthly bank statements are reconciled promptly by the accounting department supervisor and filed by date.

Required:

You recognize that there are weaknesses in the existing system and believe a chart of information and document flows would be beneficial in evaluating this client's internal control in preparing for your examination of the financial statements. Complete the flowchart, given on p. 231, for sales and cash receipts of Charting, Inc. by labeling the appropriate symbols and indicating information flows. The chart is complete as to symbols and document flows. The following symbols are used:



CHARTING, INC
FLOW CHART FOR SALES AND CASH RECEIPTS



43. The Darwin Company has performed a work measurement study on one of its clerical departments. Activities performed within that department, and the number of hours per day consumed by each activity after adjustments for rest time and slack time, are as follows:

Activity	A	B	C	D	E	F	G
Hours/day	2	3	6	3	6	5	3

The department employs four persons: Adams, Baker, Clark and Dill. Adams, Baker, and Clark work eight hours each day, from 8 a.m. to noon, and from 1 p.m. to 5 p.m. Dill works four hours each day, from 8 a.m. to noon.

The scheduling of these activities and their assignment to the employees must conform to the following conditions.

- A must be completed before B may begin.
- B must be completed before either C or D may begin.
- E must be completed before F may begin.
- A, B, D and G may be performed by only one person at a time. The other three activities may be separated among several employees working simultaneously.
- Because of internal control considerations, activity F must be performed by a different person or persons than activity G is performed by.
- G and D utilize the same machine, and thus cannot both be performed at the same time.
- No employee should spend over one-half of his time on the job performing the same task.

Required:

a) Prepare a work schedule containing four vertical columns, one for each employee, and eight horizontal rows, one for each hour between 8 a.m. and 5 p.m. excluding the noon hour. Assign each of the seven tasks to appropriate time periods within the work time of each employee. Be sure that your assignment is consistent with all of the conditions specified above.

b) Prepare in good form a work distribution table for this department's operations.

Chapter 9

The Computer Acquisition Process

The acquisition of a computer by a business organization is a complex process which requires careful adherence to the systems concept. The entire organization will feel the impact of this process and its results. The need for comprehensive organization-wide planning cannot be overestimated. Also of great importance is the need for top management interest and involvement in all stages of the acquisition process, as well as in the continuing operation of the system once the acquisition is completed.

The process of acquiring a computer has several distinct stages. The first of these stages is the *feasibility study*, which is a special form of systems survey and analysis for the purpose of deciding whether or not the acquisition of a computer system is practical. The second is the *applications study,* which involves the preparation of a detailed description of the tasks which the computer system is to perform. The third step is to receive presentations from various vendors and evaluate the relative merits of these proposals. Following a choice of vendor, the fourth major step is to prepare for installation. The fifth and final step is conversion from old to new system. The entire process may take up to two years, or even longer.

This chapter describes in some detail the nature and purposes of both the feasibility study and the applications study, and discusses the selection of equipment vendors and the methods of financing equipment acquisition. The next chapter covers the processes of preparing for computer installation and of conversion.

THE FEASIBILITY STUDY

As indicated above, the feasibility study is a special purpose systems study which concentrates on the development of recommendations regarding whether or not the organization should computerize its information system, or should acquire a more advanced computer system than the one already in use. Usually several alternatives will be considered, including modifying the existing system,

or obtaining one of several possible choices of more advanced systems. Three dimensions of feasibility should be evaluated during a feasibility study. These are technical feasibility, economic feasibility, and operational feasibility.[1] *Technical feasibility* involves whether or not a proposed system is attainable given the existing state of technology. *Economic feasibility* involves whether or not a proposed system will produce economic benefits which exceed its costs. *Operational feasibility* involves a determination of whether the system will be used and of how useful it will be within the operating environment of the organization.

The evaluation of technical feasibility can be left primarily to computer specialists, and need not concern us here. Operational feasibility must be evaluated largely on a subjective basis, but its attainment obviously depends upon the degree of involvement of top management and user groups in analysis and implementation, and upon management's regard for the human factors in systems change. These topics are covered in Chapter 8.

The evaluation of economic feasibility, the primary concern of this section, involves a careful investigation of cost and benefit factors associated with each proposed alternative. Because of his familiarity with cost concepts, the accountant can make a significant contribution to this evaluation. The basic framework for the evaluation is the capital budgeting model. This model requires that, for each alternative under consideration, dollar estimates be made of: (1) the amount of the initial outlay, (2) the amount of operating costs and other cash outflows associated with the system during each period over the life of the system, and (3) the amount of cost savings and other benefits during each period over the life of the system. The choice among alternatives is then based upon the alternative which provides the highest net present value after discounting net cash flows at the organization's opportunity cost of capital.

One of the first steps in the feasibility study is to assign responsibility for carrying out the investigation. As with any systems study, one of the significant considerations here is that the group carrying out the study should include both persons with technical knowledge and persons with knowledge of and experience in the operation of the business. If the company has no previous experience with computers, persons with technical knowledge may not be available within the organization. In some such cases, it may be possible to utilize the services of a consulting firm, particularly one which has both technical competence and some familiarity with the company or the industry. In other cases, reliance may have to be placed upon representatives of a vendor. In companies where a computer data processing function does exist, persons with technical competence can be obtained from within. To serve as a source of operating knowledge and experience, representatives should be obtained from top management, as well as from those operating areas which will be most involved in the utilization of a computer, such as accounting and production in a manufacturing company.

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[1]George Glaser, "Plain Talk About Computers," *Business Horizons*, Fall, 1967, pp. 33–38.

The initial phases of a feasibility study are very much similar to the initial phases of systems investigations generally. An emphasis should be placed upon defining objectives and delineating system requirements. The required system output includes management information, documents, files, and so forth. The existing system is subjected to a rigorous analysis to determine whether it can meet the current and future requirements in accordance with the objectives. Even though the final decision may be not to automate, the feasibility study is likely to produce some benefits through the correction of inefficiencies or the initiation of other improvements in the system.

If it is decided that the existing system may be inadequate, an exploration of possible alternatives is undertaken. A wide range of possible choices of automated systems is available, from punched card systems at the lower end of the scale to advanced real-time computer systems at the upper end. In between, the basic choices which must be made concern the type of file storage (card, tape, disc, etc.), the speed of central processing unit and peripheral devices, and the size of primary storage. An early attempt should be made by the study group to narrow the range of alternatives to a relatively small set of perhaps two or three, in order to provide a focal point for subsequent efforts at data collection and review. Technical feasibility should provide one criterion for this initial culling of alternatives.

At this point in the feasibility study, the primary basis for subsequent analysis becomes the relative economic merits of the choices under consideration. Whereas it is not too difficult to develop estimates of the initial outlay and operating costs required for a computer system, making reliable estimates of the amount of expected cost savings and other benefits can be quite a formidable task. Each of these categories of cost is now discussed in turn.

Costs of Operating a Computer System

The ongoing recurring costs of operating a computer system can be divided into three major categories: equipment costs, personnel costs, and overhead. Actually, the equipment costs may be either an operating cost if the system is leased, or a part of the initial outlay if the system is purchased. However, a majority of computer users, including a vast majority of first time users, lease their equipment. For this reason, the presentation in this section assumes a lease arrangement. The relative merits of purchasing and leasing as means of acquiring a computer system are discussed in a later section of this chapter.

Equipment costs vary over an extremely wide range. At the lower end of the scale are the *minicomputers,* which rent for under $1,000 per month. A typical configuration might include a central processing unit with four to eight thousand bytes of primary storage, a terminal interface, and tape or disk units. For business applications, a high-speed input device and printer would be required, at an additional cost. A typical minicomputer is the PDP-8 sold by Digital Equipment Corporation. Minicomputers were first applied primarily to

engineering applications, but their use in business data processing has grown significantly in recent years.

At the next level up on the hardware scale are the small computer systems offered by the major computer manufacturers. A typical configuration of this type might include a central processor with a primary storage capacity of eight to sixteen thousand bytes, a keypunch, a card reader and punch, a printer, and a disk storage unit. This type of system is typified by IBM's System 3 line. The average monthly rental for such a configuration would be $2,000 to $2,500.

A medium-sized computer installation might include a central processor with from 16 to 128 thousand bytes of primary storage, several keypunch or key-to-tape machines, four tape drives, several disk units, a card reader and punch, and a printer. Such a configuration would rent for from $12,000 to $20,000. A configuration of this type is exemplified by the IBM System 370 Model 135.

A large-scale computer system would contain one or more central processors with primary storage capacity of from 64 thousand bytes to over a million. The system would contain a large number and variety of input, output, and storage units. Typical systems of this type are the Burroughs B7500, CDC 6600, and Univac 1108. Average monthly rental of such large-scale systems ranges from $50,000 to $75,000.

Substantial as the costs of equipment rental may be, on the average they account for only 30 to 40 percent of the total costs of operating a computer installation. Personnel costs account for up to 50 percent or more of the total on the average, and thus in most cases exceed the costs associated with the equipment. A major element of the personnel cost is for software development and maintenance, which takes the form of salaries of systems analysts and programmers. Skilled people for these positions are in short supply, and so their salaries tend to be high. Also included in personnel costs are the salaries of computer operators and keypunch operators. Finally is included the salaries of supervisors for each of these categories, and of a manager in charge of the entire facility.

The remainder of the costs of operation in a computer system fall under the heading of overhead. In this classification is the cost of utilities, including power for the computer itself and for the air conditioning required by the computer, lighting, and perhaps telecommunications services. It also includes the cost of supplies, such as paper, preprinted forms, punched cards, magnetic tapes, removable disk packs, and so forth. Equipment maintenance costs and insurance costs are other elements of overhead. Building occupancy costs should also be taken into consideration if there are cash flows or opportunity costs specifically identifiable with the occupancy of building space by the computer system.

Initial Outlay Costs of a Computer System

Initial outlay costs, which represent the initial investment upon which it is expected that an adequate return will be generated, fall into several categories.

First is the cost of organizational adjustment associated with the change. Many people must be hired, both for managerial and operating positions. A great deal of testing and training must be done as part of the process. Displaced personnel should be relocated. Steps should be taken to assure that employee morale does not deteriorate as a result of the change.

A second major portion of the initial outlay will be for preparation of the computer site. Even if the site is to be part of an existing building, the cost of the remodeling necessary to accommodate a computer system is still likely to be substantial. The addition of electrical outlets, communications capacity, and raised floors will often be required.

The initial systems analysis and programming is a third element which adds to the initial outlay cost. The operating system, utility routines, compilers, and so forth are obtained from the vendor. Some vendors charge for these separately, while others provide them as part of a package with the equipment. In addition to this software, however, much time and effort will be required to program the user's applications, and to test and document them. Testing will require the use of outside equipment. The cost of converting files to the storage media of the new system can also be large, particularly if the old system is a manual one with files of printed documents.

A fourth portion of the initial outlay cost will be for the process of conversion itself. The main element of this cost arises from a period of parallel operation of the old and new systems prior to the final changeover. Such simultaneous operation of two data processing systems can obviously be quite costly. In addition, computer systems personnel work long overtime hours during the conversion period to prepare the new system for reliable operation.

Each of these activities requiring an initial outlay is part of the process of implementation, which is discussed in greater depth in the next chapter. The elements of cost attached to these activities are somewhat more difficult to estimate than operating costs. One rough rule of thumb is that such costs will be about equal to one year's operating costs. However, rules of thumb should not be substituted for careful analysis when so much is at stake in the decision.

Benefits of a Computer System

The most difficult part of a feasibility study is to place a dollar value on the benefits which will come about as the result of computerization. Several different categories of cost savings and other benefits are usually cited as justification for computer acquisition, and some of the more significant of these are briefly discussed here.

Perhaps the most common expectation is that the computer will result in cost savings due to reductions in clerical personnel. It is true that clerical cost savings are likely to represent one of the major benefits of computerization. However, from the standpoint of an analysis of cash flows it is necessary to consider the pattern of these savings over time. For example, if a policy of relocation of displaced personnel together with the reduction in hiring rates necessary

for their assimilation is adopted, the clerical cost savings will be realized gradually rather than suddenly. Furthermore, it is reasonable to expect that the computer will continue to take over clerical functions after its implementation, and will thus effect a gradual increase in clerical cost savings over time. However, it is relevant to point out that most, if not all, savings from reductions in clerical personnel may be offset by the personnel costs relating to the staffing of the computer system.

Whereas clerical cost savings usually represent the primary initial justification for computer acquisition, the primary long-term justification for the computer must be its contribution to better management. The production management function is one area where this contribution is often expected. More accurate and comprehensive information should be made available by the computer to enable production planning to be more sensitive to market conditions and to the availability of raw materials. Tighter control over waste and inefficiency in production can be accomplished with faster and more accurate production control information. Cost savings from greater production efficiency are difficult to estimate accurately, but they can be substantial. Care should be taken to separate those savings attributable solely to computerization from those which could be achieved by improvements other than computerization.

Another form of cost savings is that which arises from having fewer funds tied up in working capital. The computer can help to reduce inventory balances by keeping a more accurate and up-to-date record and by automatically reordering items which need to be replenished. Accounts receivable balances can be reduced by means of faster billing and closer monitoring of past due accounts. Cash balances can be reduced because of more accurate forecasting of cash requirements. All of the funds thus freed can be invested in income-producing projects, thereby contributing to cash inflow.

Computerization can also help an organization provide better service to its customers. Increased control over inventories means fewer stockouts. Increased efficiency in the handling of customer orders means fewer errors and faster order handling and delivery. Increased automation enables faster responses to inquiries from customers or potential customers concerning the status of their account or the availability of a product. Advantages of this type are quite difficult to quantify. Nevertheless, they are real and should not be overlooked, particularly if the company operates in a highly competitive market.

Finally, the computer benefits which are perhaps the most difficult to quantify are those relating to improvements in management. The computer will provide management with more timely, more comprehensive, and more reliable information. It will provide a basis for better management control by spotlighting the extremes of good performance and bad performance in the organization. It offers the potential for development of planning models and quantitative techniques by which to improve management decision making. Such improvements will probably be realized gradually rather than quickly,

and so estimates of their contribution to cash flow should be conservative for the first few years after computerization.

On the basis of these tentative estimates of cash flows, the feasibility study group must formulate a recommendation to either discontinue further investigation of computer acquisition and maintain or modify the existing system, or go ahead with the computer acquisition plan. This recommendation and the related decision are not likely to be easy or clear cut. As a capital budgeting decision, it should be considered relative to other investment alternatives.[2] If the decision at this point is positive, the next step is the applications study.

THE APPLICATIONS STUDY

The applications study phase of computer acquisition involves a detailed description of the tasks which the computer system is to perform. Whereas the feasibility study only considers computer applications to the extent necessary for obtaining estimates of costs and cost savings, the applications study considers each computer application in greater detail. It may seem that the applications study should be part of the feasibility study, and in fact much of the information developed in the feasibility study will be useful in the applications study. However, the purpose of the feasibility study is to obtain estimates for making a yes-or-no decision on computer acquisition. This purpose does not require the degree of detail that becomes necessary in planning for the actual acquisition and installation. It would be wasteful to complete a full applications study, only to find that the feasibility study indicates that computer acquisition would not be worthwhile.

The goal of the applications study is to produce a set of *specifications,* which will represent a very detailed description of the data processing requirements of the company. The vendors who accept invitations to present a proposal to the company are provided with the specifications for use as a basis in developing presentations which will reflect the user company's needs.

Content of Specifications

A set of specifications typically includes certain general information, a detailed description of the user's applications, and an indication of the user's expectations of the vendors with respect to their presentations. Each of these categories of information is hereby examined in turn.

General information. A set of specifications should first include general background information on the company. A concise outline of the company's facilities, products, financial circumstances, and organization serves as an appropriate introduction. This should be followed by a more extensive descrip-

[2]For an excellent treatise on capital budgeting, see Harold J. Bierman, Jr. and Seymour Schmidt, *The Capital Budgeting Decision,* Second Edition (New York: The Macmillan Company, 1966).

tion of the company's present data processing system, including major applications and existing equipment. A brief indication of the more serious inadequacies or problems with the present system could be useful here. Other general information should include the company's expectations with respect to the dates of submission of proposals and the date that the final decision on selection of a vendor will be made.

Description of applications. The heart of the specifications will be a description of proposed applications. Each application should be treated separately. One of the most important elements in the presentation of an application will be the system flowchart, showing the input to and output from the computer runs. Input to the application should be further described by its sources, the operations performed on it prior to conversion to computer input, and its average and peak volume.

A specification of the contents of the master file is also a useful part of the description of each application. The individual items which the file must contain and the number of characters required for each should be defined; this will indicate the total size of each record in the file. The frequency and method of file updating, as well as the urgency and frequency of inquiries to the file, should be included in the description. The number of records contained in the file should be given and an estimate of the rate of growth expected in this number made.

The output required of each application should also be described. The points important to be clarified are: the information to be contained in each report and its format; the average size (length) of each report; the frequency with which each report is to be prepared and the necessity for timeliness in its preparation and distribution; and the persons or locations to which each report is to be distributed.

Requirements for vendor presentation. The third major category of information to be submitted in the specifications should be a list of major items which the user company expects each vendor to cover in its proposal. Significant in this respect is first of all the hardware configuration proposed by the vendor, including a description of the central processor and its characteristics, the number and type of input and output units and a description of their speed and other vital characteristics, and the type of file media and related equipment. A topic important in the consideration of hardware will be its cost, which requires a description of alternative lease or purchase plans the vendor offers and other major terms of contract, such as length of lease and cancellation clauses. An indication of when installation could commence and an estimate of when it could be completed should also be included. Floor space required, electric power, and other aspects of the installation should be covered. Any user restrictions concerning cost, hardware characteristics, delivery date, or available floor space should be revealed.

The user will also expect the vendor to discuss system software in the proposal. Any user requirements regarding compiler languages are relevant. Any utility routines or application packages which the user feels are needed or desired should be discussed. The vendor should be expected to mention all compilers, assemblers, utility routines, and so forth which he proposes for the system and indicate what usage he is recommending for each.

The vendor should also be required to submit a proposed processing schedule for the user. This will provide some assurance that the proposed system is actually capable of meeting the user's data processing requirements. The vendor should be requested to give attention to the effects of peak processing periods on the schedule.

The user will be interested in several other types of services provided by the vendor such as: the facilities available for testing programs prior to installation; any training programs offered by the vendor for the user's employees; the amount of assistance available from the vendor during the preparation for installation and conversion; the arrangements for hardware maintenance; and the availability of backup facilities in the event of a system failure. Charges for any or all of these services should be included in the description.

Most of the major topics which would be covered in a set of specifications have been mentioned. In addition to these, the user may indicate some special requirements or restrictions that he wishes the vendor to recognize in his case. After the specifications have been provided to the vendors, the next step in the process is to await receipt of their various proposals. This is followed by the difficult process of evaluating the proposals and selecting a vendor.

VENDOR SELECTION

The vendor selection process begins with the determination of which vendors will be invited to submit proposals. The term "computer vendor" generally is interpreted as a reference to the relatively few large computer manufacturers. However, the computer industry contains a variety of firms. In addition to the computer manufacturers, other major segments of the industry include: service bureaus, time-sharing vendors, computer leasing companies, used computer brokers, peripheral equipment manufacturers, facilities management vendors, EDP consultants, and software vendors. An organization which is considering computer acquisition may find it worthwhile to consider the services of firms in several of these industry segments in addition to, or as an alternative to, the major computer manufacturers. Certainly a restriction of consideration to the computer manufacturers alone is inappropriate. For one thing, many firms in other segments of the computer industry offer services or equipment which is equivalent to that of the manufacturers, but is priced lower. For another thing, if more alternatives are considered, the likelihood that the resulting system will more closely meet the needs and objectives of the

user organization is increased. Therefore this section will briefly describe each of the major segments of the computer industry, after which the criteria for evaluating vendor proposals will be discussed.

The Computer Industry

Computer manufacturers. Each of the large computer manufacturers is involved in most or all of the industry segments listed above. The distinguishing feature of the firms in this group is their production for commercial sale of computer central processing units. The primary computer manufacturer is IBM, whose share of the computer hardware market has ranged around 70% for the past several years. The policies and actions of IBM dominate the entire industry. Other computer manufacturers have had difficulty making a profit in this environment and several have dropped out of the market completely, the most recent being RCA in September 1971.

In addition to IBM, the other major computer manufacturers, in roughly the order of their market share, are: Honeywell, the Univac Division of Sperry Rand, Burroughs, The National Cash Register Corporation (NCR), Control Data Corporation, Digital Equipment Corporation, and Xerox Data Systems. For most of these firms, the only effective way to compete with IBM has been to specialize in an area of the market in which IBM is relatively weak. For example, Digital Equipment is a leading manufacturer of minicomputers. Control Data concentrates primarily on very large and fast computers for scientific applications, and thus sells many machines to research institutions and universities. Burroughs has concentrated on the systems requirements of the banking industry, and is thus very strong in that segment of the market.

Service bureaus. A data processing service bureau is an organization which provides data processing services, primarily batch processing, on its own equipment to users for a fee. For firms which are too small to afford the considerable investment of an "in-house" computer system, a service bureau may offer an attractive alternative. Since many users are sharing the computer facilities of the service bureau, the cost to each user is only a fraction of the total cost of a computer system.

Most data processing service bureaus charge a standard rate for time or perhaps for each item processed. They may add charges for materials, or perhaps a fixed fee to cover administrative costs. Service bureaus provide generalized programs for most standard applications, or will write a specialized program for a single user for an extra fee. Utilization of service bureaus requires the physical transporting of source document input to the bureau and of processed output to the user.

In addition to the cost advantages to small users, the use of data processing service bureaus offers several other advantages. A firm which has its own computer system may arrange for backup facilities to be made available through a service bureau. Such backup facilities would be helpful during a major equipment malfunction or during a period of peak processing volume. In addition, a

service bureau may offer specialized equipment, programs, or expertise which would not otherwise be available to a computer user. Service bureaus also offer users who are awaiting installation of a new computer system an opportunity to test programs on a computer model like the one being acquired.

Use of a service bureau also has disadvantages. The most significant of these relates to data security. Since the user of a service bureau must relinquish control of vital business data to the bureau, the user should assure himself that proper control procedures are being followed and that proper security provisions are in effect. Another disadvantage is that the generalized programs offered by the service bureau may not exactly meet the data processing requirements of the user. In addition, the scheduling of a user's data processing work by a service bureau may cause the user to wait significantly longer for the work to be completed than if the user had his own facility or did the work manually.

Time-sharing vendors. A time-sharing vendor is an organization that provides for a fee the usage of a central computer and online file storage to users who obtain access through remote terminals and telecommunication lines. As with the service bureau, the primary advantage is the cost savings achieved through the sharing of a central computer system by many users. The time-sharing service differs from that of the service bureau in that the former is an online processing service, while the latter is a batch processing service. The most significant disadvantage of time-sharing is the high cost of data transmission over long distances.

The advent of commercial time-sharing services in the mid-1960's gave birth to the concept of the *computer utility.* According to this concept, computer service is like telephone or electric service, which is provided to subscribers by organizations having a monopoly on the service within a community. The computer utility would operate a large central computer system and provide service to its subscribers via telephone. Holders of this view felt that computer utilities were inevitable due to the tremendous economies of scale in computer systems. However, the uniqueness of each user's needs, the problems of data security, and the cost of data transmission have thus far prevented the large-scale computer utility from becoming a reality.

Three basic categories of time-sharing services are available. One is a problem-solving or scientifically oriented service. This type of time-sharing service is the most common and has several advantages. First, it provides computer availability to organizations not having access to private facilities at a relatively low cost which varies with usage. Second, it provides an interactive capability, which means that the user can obtain a problem solution quickly and then structure another problem based upon that solution, and so on. A third important advantage is that time-sharing vendors generally offer a large number of specialized library programs, many of which a user might find to be helpful.

The second basic category of time-sharing service is business oriented batch processing, in which the input consists of transaction data and the output consists of documents and reports. In addition to a terminal, the user of this

service may also have a special printer or other specialized input-output equipment. Because business applications generally involve high volumes of data input and output and because the cost of data transmission is high, this type of service is often not economical relative to the service bureau. In addition, the problems of data security and control are perhaps even more serious than in service bureaus because of shared file storage. The main advantage of this service is that it provides a real-time capability, which in some cases may improve the efficiency of the user's operations or provide the user with a significant competitive advantage.

The third type of service offered by time-sharing vendors is an information utility service. This service provides the user with access to a large centralized data base containing information relevant to specific needs of each user. One example related to accounting is a credit reference service. The centralized data base of such an organization contains credit information on all potential credit customers within a community. Subscribers may obtain access to this information via telephone whenever a customer applies for credit.

The cost of a time-sharing service generally includes a fixed monthly charge for the terminal and other equipment and variable charges for terminal hookup, central processor time, and file storage used. The cost of a terminal ranges from \$50 to \$200 per month, while the cost of terminal hookup varies from \$1 to \$10 per hour depending upon the distance to the central computer. The charges for central processor time and file storage are generally relatively small.

Computer leasing companies. These companies usually offer a computer user an opportunity to lease a computer system at rates below the rental rates charged by the manufacturers. Offsetting this basic advantage is the basic disadvantage that these leasing contracts are for a long-term period with no options to cancel. Thus the flexibility and avoidance of risk which is present in rental contracts with the manufacturer is not present in contracts with leasing companies.

Leasing companies utilize what is called a "sale-leaseback" transaction in which the user company purchases a system from a vendor, sells it to the leasing company, and then leases it back. According to one estimate, five percent of all computer systems in use today are financed in this manner.

Used computer brokers. These organizations operate primarily as agents for sellers of used computers, assisting them in finding a buyer. Their fee is determined as a percentage, commonly 10%, of the selling price. The market for used computers has grown significantly in recent years as the total number of computer systems in use continues to increase sharply.

Peripheral equipment manufacturers. These firms manufacture a variety of input, output, and memory devices. Though the computer manufacturers are a major segment of this group, there are a large number of independents. Relative to central processor units, peripheral equipment represents 60% of the dollar value of all computer hardware sales. From the user's point of view, the most

significant thing about this industry segment is that the independents may offer price and performance advantages over the computer manufacturers. Some may offer devices which are equivalent to those of IBM, for example, but at a lower cost. Others may offer devices which are technologically superior to those available from the computer manufacturers at equivalent prices.

Facilities management vendors. A facilities management vendor is an organization which contracts to manage the data processing facilities of a user for a fee. In most cases the hardware is owned or leased by the user and is located at the user's site. The facilities management firm operates under guidelines and schedules established by the user. Banks, insurance companies, and hospitals are among the most significant users of facilities management services.

Facilities management offers several advantages, the most significant of which is the reduction of staffing problems relating to the computer facility. Qualified EDP personnel are in short supply, and users of smaller systems have difficulty attracting qualified people and evaluating their work. Another advantage is the control of costs and efficiency which is provided by a contract which establishes a schedule and specifies a fee. Other advantages include availability of specialized knowledge and expertise, the ability to balance staff levels over periods of high and low volume, and the possibility of more effective security and control being implemented.

For the company contemplating acquisition of its first computer system, a facilities management firm can provide useful assistance in vendor selection as well as manage the system through implementation and the early period of operation. Facilities management personnel should be familiar with a wide range of equipment and software available on the market.

Facilities management does have significant disadvantages. A primary one is that a major segment of the user's operation is turned over to the control of outsiders. The personnel provided by a facilities management vendor may not be as sensitive to the needs and objectives of the user organization as would be the user's own personnel. Facilities management is probably not an appropriate alternative to consider for an organization which has an effectively operating computer system staffed with experienced and qualified personnel.

EDP consultants. The two foremost types of firms which offer independent EDP consulting services are the major private consulting firms and the large public accounting firms. Both employ people who specialize in EDP consulting. A service of this type is often invaluable to the user considering computer acquisition for the first time. With little knowledge and no experience, first-time buyers are often taken advantage of by equipment salesmen whose primary objective is to make a sale. The experience and objective viewpoint of the EDP consultant helps to assure that decisions are based upon facts and needs rather than emotions.

Software vendors. Firms in this industry segment specialize in the development of software for user organizations. Prior to IBM's unbundling of hardware and

software prices in 1969, most software development work by these vendors was done under contracts with users. The unbundling stimulated the development of a market for software products. As with peripheral equipment, the software products available from the independent software vendors may offer price or performance advantages over that available from the computer manufacturers.

Summary. Nine segments of the computer industry have been described in this section. Of these, service bureaus, time-sharing vendors and used computer brokers should be considered as alternatives at the beginning of the feasibility study. The advice of EDP consultants may be useful in carrying out the feasibility study. If the decision is made to acquire a computer system, either a facilities management vendor or an EDP consultant may provide useful assistance in preparing specifications and evaluating vendor proposals.

Once the applications study has been completed, the specifications are provided to a number of computer manufacturers (generally three to five) who are invited to submit proposals. The time lapse between providing a vendor with the specifications and receiving his proposal averages about two months. During that period each of the different vendors may desire clarification of various aspects of the specifications, and the company should be prepared to provide such guidance. In the next section, the criteria for evaluating vendor proposals are discussed.

After a vendor for the main system has been selected, the user may wish to consider alternative sources of peripheral equipment or software. Vendor selection must be followed by a decision of how to finance the computer acquisition. At this point, computer leasing companies may be considered. A subsequent section of this chapter discusses purchasing and leasing as alternative means of financing.

Evaluation of Vendor Proposals

After the proposals of all vendors have been received, the difficult choice among equipment configurations and vendors must be made. The most important factors in the selection of an equipment configuration are hardware and software performance and cost. One popular means of comparing the hardware and software performance of computer systems is the *benchmark problem.* This is a data processing task which is typical of the jobs a new computer system will be required to perform, and which therefore provides a useful means for making a comparison among proposed systems. A second approach is to develop a performance-cost ratio for each proposed system. The problem with this approach is that it is difficult to reduce all of the various aspects of system performance to a formula which is to be solved to provide a number representing a comparable measure of performance. A third approach is the use of mathematical models to simulate the performance of each proposed system relative to the complete processing requirements of the user.

A thorough analysis of the proposed processing schedule of each vendor also provides an indication of the capability of the proposed hardware and soft-

ware to accomplish the required data processing functions of the user company. Necessary for making a determination of whether the schedule allows enough time to complete each application is knowledge about rated speeds of each hardware item, including the average speed of the central processor in executing a typical mix of instructions. Since many business data processing applications are input-output bound, the speeds of input-output hardware may often determine the rate at which each application can be processed. The time required for each unit of activity multiplied by the volume of activity for each application provides a fair measure of the total time required for each in the schedule. The schedule should also make allowances for periods of peak volume.

Another significant factor in equipment selection is the compatibility of the proposed system with the user company's present data processing system. This is particularly important if the user company is already automated and is seeking to obtain more capacity. A closely related factor is the *modularity* of the proposed system, which is its capacity to be expanded with a minimum of difficulty to meet growth in the user company's needs. Modularity relates both to hardware and software. For example, the capacity of a system may be expanded by adding more primary storage, faster input-output equipment, or a faster central processor. Hardware changes, particularly a change in CPU, will require changes in software. The ease with which such changes can be made is what is referred to as modularity.

Still another important element of the equipment selection decision is the choice among vendors. The reputation of each vendor and the support which each is able and willing to provide to the user are very significant. Support consists of such things as: training for user personnel; use of equipment for testing purposes; contracts for maintenance; assistance in systems analysis and design, in implementation, and in eliminating bugs during the early stages of operation; and provision for system backup in the event of failure. The relationship between a computer vendor and a user company is complex and has many facets. During the period of implementation especially, this relationship will be a very close one. Throughout the period of their association, the user company will be placing reliance upon the vendor. The choice of vendor is thus a decision which must be carefully weighed.

The final choice of computer system and vendor is not likely to be a clear-cut decision. Each alternative may rank high according to some criteria and low according to others. The question of how to weigh the various selection criteria then arises. In the final analysis, this decision cannot be based solely upon objective criteria, but must rely to some extent on subjective factors.

Financing Computer Acquisition

Closely related to the selection of an equipment configuration and vendor is the selection of a method of financing equipment acquisition. The two primary alternatives are leasing the equipment or purchasing it. Leasing may be arranged through the computer manufacturer or through a sale-leaseback transaction involving a computer leasing company.

A typical lease contract with a computer manufacturer specifies a basic monthly rental charge which includes maintenance and parts and covers a minimum lease period of one year. Some manufacturers add an extra use charge for usage of the system for more than 176 or 200 hours during a month. Many computer leasing contracts also provide the user with an option to purchase the system at any time at a price specified by the contract.

The terms of equipment purchase from a computer manufacturer are relatively straightforward. Equipment maintenance must be handled by a separate contract payable on a monthly basis. For the protection of the user, a purchase contract may include provision for a penalty payment in the event of late delivery and a commitment to provide maintenance service during the first 90 days after installation.

Computer leasing provides several advantages over purchasing. One is flexibility, which exists in the ability to cancel the contract after any one-year period, and in the option to purchase. A second is that a large initial outlay of cash is not required for leasing. A third is the avoidance of risks which is achieved by having the ability to cancel the lease contract as opposed to being permanently "locked-in" to a purchase contract. Examples of risks are: the risk that the equipment configuration may become obsolete as more efficient and less costly equipment becomes available in the market; the risk that the equipment rented may not perform as expected; the risk that the user may outgrow the equipment configuration sooner than expected; and the risk that the level of support provided by the vendor may not be adequate.

The primary advantage of purchasing computer equipment rather than leasing it is that the total cost outlay is smaller. This factor is illustrated in Fig. 9.1, which compares total purchase and lease cost outlays over time. Since a lease contract calls for a constant monthly payment, total lease cost increases at a constant rate over time. With respect to purchase, the line labeled gross purchase cost represents the purchase price of the system plus the monthly costs of a maintenance contract. The relevant cost with respect to purchase is the net purchase cost, which is equal to the gross purchase cost minus the trade-in value of the system. The graph shows that if a computer system is used by an organization for a period of more than about two and one-half years, the total cost outlay is less under a purchase arrangement than under a lease. The cost patterns shown in the graph represent averages for the computer industry but do not reflect either the effects of taxes or the cost of capital.

One other advantage of purchasing computer equipment rather than leasing it is that the possibility of extra use charges is avoided. Tax advantages are also obtained from purchasing in that an investment tax credit can be taken and accelerated depreciation can be deducted for income tax purposes.

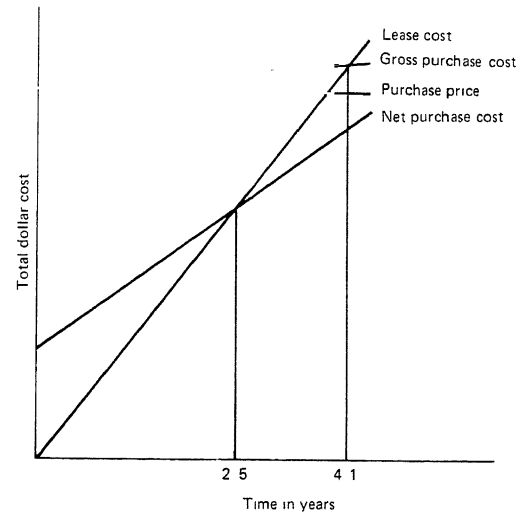


Fig. 9.1 Comparison of total costs of purchasing and leasing computer systems over time.

REVIEW QUESTIONS

1. Define the following terms:

   feasibility study
   applications study
   technical feasibility
   economic feasibility
   operational feasibility
   minicomputer
   specifications
   computer utility
   benchmark problem
   modularity

2. How does the systems concept relate to the computer acquisition process?
3. What are the five stages of the computer acquisition process?
4. Identify three dimensions of computer feasibility and explain how each should be evaluated.
5. What should be the qualifications of the persons who carry out a feasibility study?
6. Outline and briefly describe the steps in a feasibility study.
7. What are some of the basic choices which must be made in selecting a computer data processing system?
8. What three categories of cash flow estimates should be made during a computer feasibility study? List several individual elements within each category. Once these estimates have been made, what basic framework should be used in evaluating the feasibility of alternatives?

9. Briefly describe a typical equipment configuration for representative small-, medium-, and large-sized installations. What would be an average monthly rental for each?
10. List several categories of personnel which are necessary in a computer system. How does the total operating cost expended for personnel generally compare with the total operating cost expended for equipment in a computer system?
11. What is the difference between a feasibility study and an applications study? Why should they not both be performed together?
12. What is the goal of an applications study?
13. Outline and briefly describe the content of a set of specifications.
14. Describe in detail the information which should be contained in a description of input, files, and output for an application in a set of specifications.
15. Describe in detail the information which a company should request a vendor to include in its presentation of a proposed computer system for the company.
16. List and briefly describe nine major segments of the computer industry. At what point in the computer acquisition process would the products or services of each segment be considered?
17. List several criteria which should be used by a company to select a computer vendor from among several which have presented proposals.
18. Explain how the capability of a proposed computer system to meet a processing schedule can be evaluated.
19. Identify some of the primary characteristics of lease and purchase contracts between computer manufacturers and computer users. What are the relative merits of leasing and purchasing computer equipment from the standpoint of the user?

DISCUSSION QUESTIONS

20. Discuss the role of the accountant in the computer acquisition process. Should the accountant play an active role or should all of the work done be left to computer experts? In what aspects of computer acquisition might the expertise of the accountant produce a useful contribution.
21. Computer manufacturers generally employ very competent personnel who will assist a customer in designing a system for no charge or for a relatively small fee. Being good businessmen interested in repeat sales, representatives of a computer manufacturer will certainly consider very seriously the needs and objectives of the customer. Why then should a

firm contemplating the acquisition of a computer system for the first time consider employing the relatively expensive services of an EDP consultant?

22. While reviewing a list of benefits from a computer vendor's proposal, you note an item which reads "improvements in management decision-making – $50,000 per year." How would you interpret this item? What influence should it have on the computer acquisition decision?

23. You are participating in a feasibility study for a company which is considering the acquisition of its first computer system. The company's management has decided that a warehouse adjoining the main plant should be used to house the computer system if it is acquired. This warehouse was built only five years ago, but the company has not used it since discontinuing a major product line three years ago. The warehouse was rented briefly to another firm, but is not presently in use for any purpose.

    You feel that the warehouse would make an excellent location for a new computer facility. How should a cost of space utilization for the computer facility be determined for inclusion in the feasibility study? Discuss.

PROBLEMS AND CASES

24. You are an administrative services specialist for the CPA firm of Xeron, York, and Zapata. The Avalon Electronics Company, one of your firm's clients, has asked you to study for them the feasibility of computer acquisition. The company has a sales volume of $6,000,000 and has been having some problems with profit margins, making only a 2% return on sales as opposed to the industry average of 10%.

    The applications which Avalon would like to automate initially are payroll, accounts receivable and billing, parts inventory, finished goods inventory, and general ledger. A need for frequent inquiry into the parts inventory and finished goods inventory files exists. The firm also expects to grow by a factor of 50% in the next five years. You have determined that the required equipment configuration includes a central processor with 12,000 character storage capacity, a disk drive unit with five million character storage capacity, a card input-output unit which reads at 250 cards per minute and punches at 60 cards per minute, a printer which operates at 200 lines per minute, two keypunches, and one teleprinter terminal. Monthly rental for a configuration of this sort would be $1,935.

    You estimate costs of systems personnel as follows: one systems analyst-programmer at $800 per month, one operator at $500 per month, and one full- and one half-time keypunch operator at $400 and $200 per month, respectively. Monthly rental of software would total $65 per month and other miscellaneous overhead would total about $300 monthly.

Set-up costs for this system would include the purchase of six applications programs at a cost of $1,350 and additional expenditures for site preparation, file conversion, and initial programming and testing which would total approximately $3,650.

You have estimated that the new computer system would generate cost savings in two primary areas, which are clerical costs and inventory carrying costs. Implementation of the new system would initially reduce the number of people in accounts receivable and billing from 4 to 1 and in payroll from 2 to 1. Each of these employees makes $500 per month. Also the number of people in the parts inventory section could be reduced from 4 to 2. These people each make $400 per month.

You feel confident that the increased efficiency in reordering and control of parts inventory resulting from computerization would reduce the company's inventory balance of $375,000 by 20%. The funds thus freed would generate savings at an annual rate of 10% (the firm's cost of capital).

Although you did not attempt to estimate their dollar amount, you feel that significant intangible benefits would accrue to the firm if it acquired a computer. These include improved production efficiency, better customer service, and better management reports and decision making.

You have estimated that Avalon's hardware requirements will grow at a constant rate over the next five years. During the fifth year of this period, the equipment configuration will include a CPU with 16,000 character capacity, an additional disk unit, and an additional keypunch. The monthly rental for this configuration would be $600 higher than for the initial configuration. In addition, another full time keypunch operator, at $400 per month, would be required, and monthly overhead costs would increase by $200.

If Avalon does not computerize, in five years 6 people will be needed in accounts receivable and billing instead of 4, 3 will be needed in payroll instead of 2, and 6 will be needed in parts inventory instead of 4. The salary levels of the new people would all be the same as for the current employees. If the firm does computerize, no new people would be required in these areas in five years, and in addition the accounts payable and job order cost functions could be computerized by that time, saving a net of three additional employees whose salary is $500 each.

Also assume that the amount of cost savings from inventory reduction would increase by 60% in five years.

Required:

a) Calculate the total monthly operating costs required for the proposed system and the total monthly cost savings from personnel reductions and inventory reductions.

b) Calculate the total monthly operating costs for the system in the fifth year and the total monthly cost savings in the fifth year from personnel reductions and inventory reductions.

c) Assume that one of the former accounts receivable clerks would become the computer operator and one of the parts inventory clerks would become the full-time keypunch operator. The other four persons whose jobs were eliminated would be assigned to special projects. Due to normal employee turnover these latter four employees would be assimilated into the regular office staff within an average of six months. Further assume that total operating costs and cost savings will rise by equal dollar amounts in each year from year 1 to year 5. Prepare a schedule of annual cash flows over the five-year period. (Ignore the effects of taxes.)

d) All things considered, would you recommend that Avalon acquire a computer at this time? Why or why not?

25. The Valentine Company is acquiring a new computer system, and must decide how the acquisition is to be financed. If the system is purchased, it will cost $550,000, and the separate maintenance contract will cost $2,000 per month. An investment tax credit of 7% could be taken. The machine would be depreciated using the sum-of-years-digits method with an estimated useful life of ten years. Assume a marginal income tax rate of 50%. Trade-in value of the machine would be about $360,000 at the time of purchase, and would decline at approximately $3,000 per month for each month thereafter. Assume that there is no salvage value.

If the system is leased, the monthly payment will be $12,000 per month, which includes maintenance. There will be no extra-use charges. The lease contract could be canceled at the end of any one-year period at no penalty. An option to purchase is included in the lease contract which specifies that the customer may purchase the system at the end of any year at the following prices:

End of year	1	2	3	4	5	6-10
Purchase price	$500,000	$430,000	$360,000	$290,000	$220,000	$150,000

Required:

a) Prepare for both the purchase and the lease situation a schedule of cash flows at the beginning of the first year and during each year for ten years afterward.

b) Determine the break-even point for purchasing relative to leasing. This is the point in time, in years and months, at which the net purchase cost is exactly equal to the total cumulative cost of leasing.

c) Considering only the cash flow considerations and ignoring the effects of discounting of cash flows, which of the two choices is more attractive?

d) If the cash flows were discounted, how would this affect the relative attractiveness of leasing and purchasing?

e) Cite some factors in addition to those mentioned above which would have some bearing on the decision.

Chapter 10

Systems Implementation

After the systems analysis and design have been completed and management has approved the recommendations of the systems study group for system modification or choice of a vendor from whom to acquire equipment, the focus of the systems investigation is transformed dramatically from the realm of analysis, deliberation, and creative thinking to the realm of action. The plans and theories of the systems study group must be put into practice in the arena of the real world. This period of time, between the acceptance of recommendations by management and the acceptance of the new system as an operational success, is referred to as the period of systems implementation.

Depending upon the size of an organization and the level of sophistication of its information system, a systems implementation project could involve either a major revision to a manual system, conversion from a manual to an automated system, or conversion from an automated system to a larger and/or more advanced automated system. Within a computer system, implementation often refers to the development of and conversion to a major software system. However, systems implementation generally involves the performance of a fairly well-defined set of activities. The first section of this chapter will discuss the steps in the implementation process, using implementation of a computer system as the primary point of reference. The second and final section of the chapter provides an extensive discussion of PERT (Program Evaluation and Review Technique), which is a commonly used technique for the planning and scheduling of complex projects such as systems implementation.

THE IMPLEMENTATION PROCESS

Any major implementation project will involve the following activities: planning and scheduling of the implementation process, organizational planning and personnel administration, final systems design and testing, establishment of standards of performance and control procedures, site preparation, conversion from old to new system, and follow-up review and evaluation of results. This section discusses each of these activities in detail. Whereas most of the discus-

sion relates directly to computer implementation, many of the concepts also apply to major revision of manual systems or major software development projects.

Planning and Scheduling

During the implementation period, many varying activities will be proceeding simultaneously. A great deal of planning and coordination is necessary to assure that these activities are accomplished smoothly and with dispatch. Responsibility for the performance of each function must be fixed, and a timetable for the completion of each task must be established. Estimates of the cost of each activity must be developed for purposes of preparing a financial budget. Provisions should be made for monitoring the performance of all activities and making adjustments where necessary to assure continued progress. The PERT technique provides an explicit framework for scheduling, coordination, expediting, and monitoring the progress of the implementation effort.

Organizational Planning and Personnel Administration

Any change in established routines of work in an organization requires attention to the human factors involved in the change. As in systems analysis and design, the participation of employees in the process of implementation will tend to prevent serious problems of resistance to change. A policy of communicating openly and honestly with employees during this period is advisable. Management and the systems group should be alert to sense any deterioration in employee morale or other serious problems, and should be prepared to take appropriate steps to deal with such problems.

For a company which is acquiring a computer for the first time, the areas of personnel and organization planning will require much greater attention than for a company which is merely converting from one computer system to another. The latter company will experience many of the same problems, but on a much smaller scale. Examples of problems which are commonly confronted are: communication with employees, adjustment of organization structure, selection of personnel, relocation of displaced personnel, and personnel training.

Communication with employees. The period prior to computer installation can be a very difficult one from the standpoint of an organization's relationship with its employees. Once the fact is known that a computer will soon be installed, the natural reaction of employees to the uncertainty of the situation is one of apprehension. If it remains unchecked, such apprehension could well degenerate into an attitude of resistance and distrust.

If proper employee relations policies are adhered to during the initial period of systems survey and analysis, communication with employees prior to computer installation will follow naturally. Employees should be made aware of the possibility that the organization will undergo a major systems change, and they should be informed of management's plans for personnel in the event

of such a change. Management must now provide evidence that it fully intends to honor the reassurances made during the survey. Specific plans relating to relocation of displaced personnel, staffing of new positions from the existing employee group, training programs offered to employees, and so forth should be announced. Even though such announcements may not placate everyone in the short run, their long-run effect will almost certainly be better than a policy of silence or glib reassurance. Either of these latter policies is likely to generate resentment, resistance, and a loss of morale among employees, and perhaps cause the company to lose employees with a high potential for success in the new system.

Announcements to employees regarding computerization should always emphasize the positive aspects of the change – opportunities to devote more attention to the creative aspects of one's job while the computer performs the routine functions, opportunities for more rapid advancement and higher salaries, and so forth. The need for cooperation of employees at all levels of the organization to facilitate successful implementation should be stressed. Throughout the entire employee relations effort, the interest and concern of top management should be made clear.

Adjustment of organization structure. A company's first venture into computerization of data processing will require significant adjustments to its organization structure. A new set of departments will have to be staffed. Major categories of jobs to be established and defined include analyst, programmer, computer operator, and various managers. The problem of the appropriate level in the organization structure for the head of data processing will have to be resolved. The structure of the data processing department itself will have to be established. Even a company which is converting from an existing computer system to a larger or more advanced system may be faced with problems of expansion of the data processing organization, or a major change in its status in the company organization.

Selection of personnel. Once the personnel needs have been specified, the task of filling these needs must begin. Considerations relating to employee morale indicate that employees whose jobs may be replaced or significantly altered by computer acquisition should be given the first chance at testing for positions in the new system. It may even be easier to train these people in computer operations than to orient computer specialists to the company's operations and procedures. It is likely, however, that some positions will have to be filled by outsiders.

Once again the problems faced by a company which is computerizing for the first time are much greater in the area of personnel selection than for other firms. Such a company should probably seek professional assistance for this purpose. Usually such assistance can be obtained from the vendor. Computer work demands a unique set of aptitudes and abilities, including logical thinking, attention to detail, problem-solving ability, and capacity to tolerate frustration and hard work. Selection of supervisory personnel in this field requires even

greater care. These problems are compounded by the existence of a shortage of qualified computer specialists in the labor market.

Relocation of displaced personnel. Computerization will result in the elimination of a number of clerical and some supervisory positions. The manner in which this problem is approached will have a significant effect upon employee morale and loyalty. As stated above, some of these employees may be capable of obtaining positions in the new system. Others may be transferred to other departments within the organization. Since the period of preparation for installation will extend up to a year or more, the suspension of hiring when combined with the normal rate of attrition, which is generally high among clerical employees, may effect a partial solution to the problem of personnel displacement. For those employees who are nearing retirement age, the opportunity for early retirement can be provided. In those cases where there appears to be no alternative to termination of an employee's services, he should be given a generous separation bonus and assistance in finding a comparable position in another organization.

A company's treatment of personnel displaced as a result of computer acquisition will affect not only the loyalty and morale of employees directly affected, but of all employees throughout the organization. A company's actions in this regard will be interpreted as a reflection of its attitude toward its employees in general. The problem is even more serious as it relates to displaced supervisors, who may have given many years of loyal service to the company, and who will probably be most difficult to relocate in comparable positions. Careful planning and an attitude of social responsibility are requisites for the organization to successfully resolve these problems.

Personnel training. The task of training employees for their positions in the new system is one for which assistance from the vendor is usually available. Special classes in programming and computer operation are conducted by most computer manufacturers. Training of analysts and supervisory personnel must be much broader in perspective, with emphasis on orientation to the company's operations and policies as well as on technical factors. Personnel in areas of the organization outside of the computer activity should not be neglected in this process. Such personnel should be given orientation sessions designed to develop their understanding of the new system and what it can accomplish for them. Top and middle level managers should be encouraged to make requests for information and reports that would be useful to them and which could be made available under the new system.

Final Systems Design

A major step in the implementation process is the detailed design and testing of the new system. The recommendations developed during the survey and analysis and approved by management provide the basis for this process. Before a newly designed system is implemented, it must be subjected to extensive

testing to establish its feasibility and reliability. Documents and reports, processing procedures, computer programs and so forth should all be given a trial run in circumstances as realistic as possible.

With respect to computer implementation, the specifications developed in the applications study provide the basis for detailed systems design. The content and format of inputs, outputs, and master files must be established for each individual application. Program flowcharts will then be developed, to be followed by coding of the program. Each program must then be checked, debugged, and tested, which activities will require use of outside equipment, generally provided by the vendor. The testing phase will involve the preparation and running of test data designed to check a program's response to all possible conditions which it may encounter. Appropriate controls and routines for dealing with input errors and other unusual situations should be incorporated into each program. System documentation should be developed and a processing schedule for the new system established. Other important activities in the final design phase include planning and scheduling of conversion and procurement of forms and other supplies for the new system.

Establishment of Standards and Controls

An essential aspect of the final systems design phase of implementation is the establishment of job performance standards and control techniques and procedures for the new system. Often these factors are not considered until after the new system becomes operational, and this can lead to many unanticipated problems. Planning for assignment of job responsibilities must take internal control considerations into account. Job descriptions and work schedules should make provision for the execution of control procedures. Personnel selection should be affected by the performance standards attaching to each position to be filled. Documentation standards and data security provisions should be formulated. Error checks should be built into all computer software systems. A system of continuous planning for and evaluation of the new system should be devised. The significance of these various factors is such that the next chapter is devoted entirely to an extensive treatment of them.

Site Preparation

Once a specific equipment configuration has been selected, requirements for a site can be determined and work can begin on the selection and preparation of the site. A computer site should be as centrally located as possible to facilitate the frequent communication required between the computer activity and all other operations in the organization. Space will have to be provided not only for equipment and operators, but also for storage of cards, tapes, and other supplies, and for the offices of analysts, programmers, and supervisors. The site should be laid out to facilitate efficient operation. The possibility of future expansion of the system should also be considered in site selection and preparation.

Computer installation may require extensive physical changes in the location selected. In some cases the building itself may have to be expanded. Additional electrical outlets, data communications facilities, lighting, and air conditioning will be required. Security measures such as fire protection and emergency power supply should also be provided. Generally site preparation can be quite costly, but it usually does not create major problems, such as those which may be encountered in connection with personnel adjustments and systems design. The vendor is usually able and willing to provide competent assistance in this task.

Conversion

One of the first major activities in the conversion phase of systems implementation is the conversion of master files from old to new system media. If the old system is a manual one, this process will be difficult and time consuming. It will involve transcribing the data from each record on file to the new storage medium, which could be ledger cards, punched cards, magnetic tape, or magnetic disk. Care must be taken to ensure the reliability of the data converted. If the system conversion is from one computer system to another, the conversion of files from one computer data media to another will not generally be a significant problem.

If the program of preparation for installation has been adequately planned, the installation of the equipment should occur almost simultaneously with the completion of program testing, conversion of files, employee training, and site preparation. The next major activity during the period of conversion is *parallel operation* of new system and old system to provide a final test of the new system. Both systems will be operated on a full-time basis, and their output compared. Differences must be analyzed to determine their cause, and the new system should be modified where appropriate.

The period of parallel operations is one of the most costly and demanding in the entire computer acquisition process. Most employees connected with the project will be required to work long hours of overtime to operate both systems, compare results, and make necessary adjustments. These factors argue for minimizing the length of this period. However, successful implementation will require extensive testing of the reliability of the new system, and this fact argues for a longer period of parallel operations. Generally, three or four parallel runs of each application are sufficient to eliminate most of the major problems in a newly designed system. Since some applications will be run daily, others weekly, others monthly, and so forth, the period of parallel operations will be very hectic for a month or two, and then gradually wind down to final conversion after three or four months.

Many small organizations do not have the manpower, or cannot afford the expense, for a full parallel operation. An alternative approach to final systems testing is called a *pilot operation.* This form of testing involves a sample of transactions. The sample may include historical records which have already

been processed, or artificial transactions devised to test the system under various unusual conditions. The results of such tests would be compared to those previously generated by the manual system, or to those predetermined for artificial transactions. Since the volume of sample transactions is much smaller than regular processing volume, a pilot operation is less expensive and time consuming than parallel operation.

Follow Up

After a new system has been in operation for a brief period, perhaps two to four months, the systems group should perform a follow-up analysis and appraisal of its performance. The analysis should be designed to reveal and correct any weaknesses in the new system which have become evident. The extent to which the new system is meeting its planned objectives should be evaluated. The adequacy of standards and controls to keep the system operating as expected should be assessed. Major differences between actual and expected performance should be brought to the attention of management, and necessary adjustments should be initiated. The system should be analyzed through observation and interviews with employees to discover weaknesses, which should then be corrected. Even after the system review study is complete, continuous attention should be given to the possibility of correcting weaknesses and improving the system.

PERT: A PROJECT SCHEDULING TECHNIQUE

The Program Evaluation and Review Technique is a useful management tool for planning, coordinating, and controlling large, complex projects such as computer implementation. The development and initial application of PERT was done in connection with the development of the Polaris submarine by the U.S. Navy in the late 1950's. PERT has since been used for many applications in business. An extensive discussion of PERT is presented here to develop an understanding of and appreciation for the usefulness of this analytical technique in systems implementation.

PERT Concepts and Definitions

The PERT technique involves the diagrammatical representation of the sequence of activities comprising a project by means of a network consisting of arrows and nodes (see Fig. 10.1). Arrows in a PERT network represent "tasks" or "activities," which are distinct segments of the project requiring an expenditure of time and resources. Nodes in a network symbolize "events," or milestone points in the project representing the completion of one or more activities and/or the initiation of one or more subsequent activities.[1] An event is thus a point in time and does not consume any time in itself as does an activity.

[1] In a variation of these conventions used by some PERT analysts nodes represent activities and arrows represent the time sequence of activities.

Activity	Time (days)	Predecessor activities
A	3	None
B	8	None
C	6	A
D	0	A
E	7	B,D
F	4	C

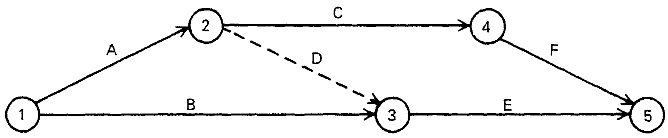


Fig. 10.1 A simple PERT network.

The first step in applying PERT to project planning is to determine all of the individual tasks in the project which are separate and distinct from all other tasks. Then all of the immediate predecessor tasks must be established for each task. That is, if task A is the immediate predecessor of task B, then task A must be completed before task B is begun, and task B may be begun immediately upon completion of task A. Some tasks may have several immediate predecessors, and such a task may not be begun until all of its immediate predecessors have been completed. Once all of the activities in a project have been determined and their precedence relationships established, the PERT network can be drawn.

One of the primary aspects of the PERT technique is the analysis of the network in terms of the time required to complete each activity and the project as a whole. For each separate activity an estimate of completion time in hours, days, weeks, or months must be made. Once this is completed, the next step is to determine the network's *critical path*, the path of activities from beginning event to ending event which requires the greatest total expenditure of time. The sum of the estimated activity times for all activities on the critical path is the total time required to complete the project. These activities are "critical" because any delay in their completion will cause a delay in the project. Activities not on the critical path are not critical, since they will be worked on simultaneously with critical path activities and their completion could be delayed up to a point without delaying the project as a whole.

Consider the simple PERT network illustrated in Fig. 10.1. Note how the network itself is constructed from the precedence relationships shown in the figure. The example illustrates a common PERT convention – the labeling of activities with capital letters, and of events with numbers. Also illustrated is a new concept, the "dummy activity," D, represented by the dashed arrow in the network. This activity is not really an activity at all in that it does not require any expenditure of time or resources. However, it is required in the network to

show that activity A is an immediate predecessor of activity E. This relationship could not be represented by routing the arrow symbolizing activity A into the node preceding activity E, for that would imply that activity B is an immediate predecessor of activity C, which is not true.

There are only a total of three paths through the network of Fig. 10.1. A comparison of the total time required for each of these paths reveals that the path consisting of activities B and E requires the greatest total expenditure of time, 15 days, and is therefore the critical path. The paths consisting of activities A, D and E; and of A, C, and F require a total of 10 and 13 days, respectively. Activities not on the critical path can be delayed without delaying the project, and are thus said to have a quantity of "slack time." Since any delay in a critical path activity will delay the project as a whole (in this case beyond 15 days), critical path activities have zero slack time. A procedure for calculating the quantity of slack time for all activities not on the critical path will be presented shortly.

Most projects to which PERT is applied are sufficiently complex that the total number of paths through the network will be quite large. Thus a more efficient procedure for finding the critical path must be used than complete enumeration of all paths. The first step in such a procedure is to find the earliest completion time for each activity and event in the network, proceeding in sequence from early events to later events, or from left to right in the network itself. The earliest completion time for an event is the greatest of the earliest completion times of all activities immediately preceding the event. The earliest completion time for an activity is the sum of the estimated time for the activity and the earliest completion time of its predecessor event. The earliest completion time for the final network event is the total required project completion time.

In terms of the illustration of Fig. 10.1, the earliest completion time for activity A and event 2 is three days, and for activity B is eight days. For event 3 the earliest completion time is the greater of the earliest completion times of the two activities preceding it, namely B and D. The earliest completion time for activity D is the zero days for the activity itself plus the three days earliest completion time for its predecessor event 2, or three days. This is less than the eight days earliest completion time for activity B, which indicates that the earliest completion time for event 3 is eight days.[2] Extending this analysis, we find that the earliest completion time for activity C and event 4 is six plus three, or nine days. The earliest completion time for activity F is 13 days, and for activity E is 15 days. Therefore the earliest completion time for event 5 and for the project as a whole is 15 days.

The next step in the procedure for finding the critical path is to find the latest time that each activity could be completed without delaying the project

[2]This point is often confusing to students, who point out that the quickest path to event 3 is the path consisting of activities A and D, which takes only 3 days. To eliminate this misconception note that *all* of the activities in the network, including A, B, and D, must be performed, and event 3 represents the completion of *both* activities B and D.

beyond the total required time already determined. For activities terminating at the ending project event, the latest time is equal to the total required project time. Determination of the latest time for other activities in a network can be done most easily by starting with activities near the end of the network and proceeding from right to left to activities at the beginning of the network. The latest time for an event and for all activities leading into that event is equal to the smallest of the remainders obtained by subtracting the activity time for each activity starting at the event from the latest time for the activity. Again referring to the illustration of Fig. 10.1, the latest time for activities E and F is 15 days. The latest time for event 4, and therefore activity C, is 15 minus 4, or 11 days. The latest time for event 3, and therefore for activities B and D, is 15 minus 7, or 8 days. To determine the latest time for activity A, the comparison mentioned above must be made. The latest time for activity C minus the activity time of C is 11 minus 6, or 5 days. The latest time for activity D minus the activity time of D is 8 minus 0, or 8 days. The smaller of these two figures, 5 days, is the latest completion time for event 2 and activity A.

Continuing the procedure, the next step is to calculate the slack time for each activity. An activity's slack time will be equal to its latest completion time minus its earliest completion time. The earliest, latest, and slack times for all activities in the sample problem are summarized in Fig. 10.2. Critical path activities are identified by the slack time calculation. All activities revealed by this calculation to have zero slack time are critical path activities. Note that it is possible for a network to have more than one critical path. For example, if the time required for activity A in this illustration had been five days instead of three, the path containing activities A, C, and F would also have been a critical path.

Knowledge of which activities in a project are critical is extremely useful to management for planning and control purposes. There is usually ample reason for management to desire to complete a project as quickly as possible. A major reason is that while resources such as manpower and equipment are at work at one job, they cannot be put to work on other jobs. Waste and inefficiency in resource utilization can be very expensive in terms of revenue lost (sometimes called opportunity cost). The faster one project can be completed, the faster the resources used on it can be transferred to other revenue producing activities.

For planning and control purposes, a critical path activity is obviously one which requires a maximum of management attention if the total project completion time is to be minimized. Such activities should be monitored very closely to assure that delays in their completion will be rendered unlikely. On the other hand, activities not on the critical path require less management attention and monitoring. The larger the slack time for an activity, the less closely it needs to be monitored.

The PERT technique is not only useful at the beginning of a project, but also throughout the entire period during which the project is being worked on. As individual activities are completed, their estimated completion times can be replaced in the network by their actual completion times. This adjustment may

Activity	Earliest Time	Latest Time	Slack Time
A	3	5	2
B	8	8	0
C	9	11	2
D	3	8	5
E	15	15	0
F	13	15	2

Fig. 10.2 Solution data for sample problem.

cause the critical path itself to change, and so the slack time for all activities needs to be continually recalculated to provide a basis for dynamic project control. As work on the project proceeds, a measure should be maintained of how much ahead or behind schedule the project is. If the project is behind schedule, the network can be used to determine which activities are the best candidates for an effort at acceleration of completion times. Thus PERT can be a useful management tool during the entire period of project execution.

PERT Applied to Computer Implementation

Figure 10.3 provides an illustration of a PERT network representing the activities involved in implementing a computer system. The activity times shown in the illustration correspond to those required for a medium- to large-scale installation. A smaller size installation might require less time, whereas a very large installation might require more time, but the activities and precedence relationships represented by the network itself are applicable to any computer implementation project.

For review purposes, the reader should verify that the critical path for this network consists of activities B, C, F, H, I, J, K, and M, that the total required project time is 83 weeks, and that the slack times for activities A, D, E, G, and L, are 5, 5, 27, 13, and 21 weeks, respectively.

Other Applications of PERT

PERT generally is useful to the administration of complex projects of a nonroutine or nonrecurring nature. For an operation which is routine or repetitive, such as mass production, a great deal of past experience is generally available for planning and control purposes. PERT is of little use in such a situation. Some of the most common and successful applications of PERT have been to research and development activities, construction projects, and the marketing of new products.

PERT with Uncertain Time Estimates

In a real world application of PERT to a complex project, the estimates of completion times for activities will seldom be certain. To cope with the un-

Activity	Time (Weeks)	Predecessor Activities	Activity Description
A	36	none	physical preparation (including vendor lead time)
B	4	none	organizational planning
C	2	B	personnel selection
D	2	A	equipment installation
E	10	C	personnel training
F	15	C	detailed systems design
G	9	F	file conversion
H	4	F	establish standards and controls
I	9	H	program preparation
J	9	I	program testing
K	20	D,E,G,J,	parallel operations
L	8	I	finalize system documentation
M	20	K,L	follow-up

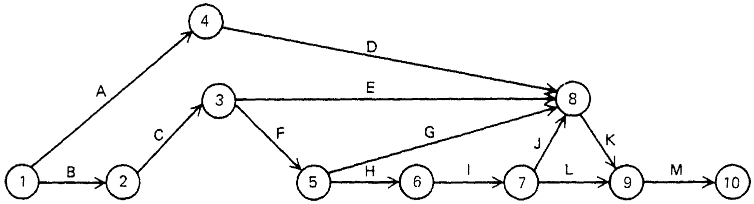


Fig. 10.3 PERT network of the computer implementation process.

certainty in activity time estimates, the application of PERT in practice usually proceeds by estimating three possible duration times for each activity. These are a most optimistic estimate of required time (labeled a), a most likely estimate (m), and a most pessimistic estimate (b). A weighted average of these three time estimates is then calculated to establish the "expected completion time" for the activity. The weighted average formula applies a weight of one to the most optimistic and most pessimistic estimates and a weight of four to the most likely estimate. The formula is thus as follows:

$$\text{Expected time} = \frac{a + 4m + b}{6} .$$

The expected completion time may be looked upon as an average or mean figure. While this formula has nothing in the nature of a theoretical proof to support it, in actual applications it has been proven to provide time estimates

which are accurate enough to be more useful than the single-valued estimate, which often turns out to be too low.

A measure of the relative dispersion of completion time around the expected completion time for an activity is the standard deviation. A formula for computing the standard deviation of completion time for an activity from the estimates of most optimistic and most pessimistic time is as follows:

$$\text{Standard deviation (activity)} = \frac{b-a}{6}.$$

Again this formula has no theoretical justification, but has been proven in practice to provide a reasonably accurate measure of dispersion.

When expected activity times and their standard deviations are computed in this manner, the PERT network is solved using the expected activity times. The total required project time obtained is thus an expected or mean time. Therefore the probability that the project will be completed within this expected total time is exactly 0.5 or one half. The standard deviation of total project time around this mean expected time is computed using the following formula:

$$\text{Standard deviation (project)} = \sqrt{\begin{array}{l}\text{The sum of the squares of}\\ \text{the standard deviations of}\\ \text{all critical path activities}\end{array}}$$

Using this standard deviation and a table of areas under the normal curve, the probability of completing the project within any given time period can be determined.

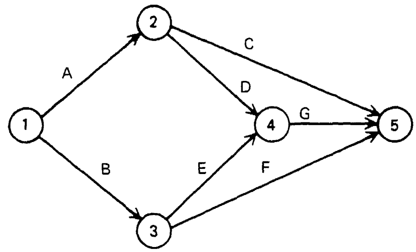
PERT Under Uncertainty: An Example

Consider the PERT network shown in Fig. 10.4. Estimates of most optimistic, most likely, and most pessimistic completion times in days for each activity are given. In addition, the expected completion time and standard deviation for each activity have been computed according to the above formulas and are also included in the illustration. The reader should verify the accuracy of these calculations, and should also verify that the critical path consists of activities A, D, and G with a total expected project completion time of 23 days.

Calculation of the standard deviation of completion time for the project as a whole according to the formula is as follows:

$$\begin{aligned}\text{Standard deviation (project)} &= \sqrt{2^2 + 2^2 + 1^2}\\ &= \sqrt{9}\\ &= 3.\end{aligned}$$

The usefulness of this approach stems from the determination of the probability of getting the project finished within some specified time period. For example,



Activity	A	B	C	D	E	F	G
Most optimistic time	6	5	4	4	4	4	2
Most likely time	9	8	7	7	7	10	5
Most pessimistic time	18	17	22	16	10	22	8
Expected time	10	9	9	8	7	11	5
Standard deviation	2	2	3	2	1	3	1

Fig. 10.4 Sample PERT network with related time data.

suppose we want to know the probability of completing the project in 27 days or less. The first step is to compute z, which is the number of standard deviations from the mean represented by our given time of 27 days. If we label the given time G.T., the mean expected time E.T., and the project standard deviation S.D., the formula for z is as follows:

$$z = \frac{\text{G.T.} - \text{E.T.}}{\text{S.D.}} .$$

For 27 days, z is computed as follows in this example:

$$z = \frac{27 - 23}{3}$$

$$= 1.3.$$

The next step in this analysis is to find the probability associated with the calculated value of z by referring to a table of areas under the normal curve such as that shown in Fig. 10.5. In the example, a z of 1.3 corresponds to a probability of .90320. This is interpreted to mean that the probability of completing the project within 27 days or less is .90320. For review purposes the reader may wish to verify that the probabilities of getting the project done within 17, 20, and 29 days are .02275, .15866, and .97725, respectively.

Knowledge of the probabilities associated with various possible values of project completion time may be very valuable to management for planning purposes. It allows management to judge the probable length of time for which the resources required for the project will be tied up at work on the project and therefore unavailable for other useful work. If management can also estimate the cost per day of utilization of the resources, the probability of various total costs for the project can be determined. For example, if the cost per day of the resources required for the sample problem of Fig. 10.4 is $1,000, then the prob-

z = Number of standard deviations from the mean

P = Probability that the actual value of the variable will be Z or less

z	P	z	P	z	P
−3 0	00135			1 0	84134
−2 9	00187	−0 9	18406	1 1	86433
−2 8	00256	−0 8	21186	1 2	88493
−2 7	00347	−0 7	24196	1 3	90320
−2 6	00466	−0 6	27425	1 4	91924
−2 5	00621	−0 5	30854	1 5	93319
−2 4	00820	−0 4	34458	1 6	94520
−2 3	01072	−0 3	38209	1 7	95543
−2 2	01390	−0 2	42074	1 8	96407
−2 1	01786	−0 1	46017	1 9	97128
−2 0	02275	0 0	50000	2 0	97725
−1 9	02872	0 1	53983	2 1	98214
−1 8	03593	0 2	57926	2 2	98610
−1 7	04457	0 3	61791	2 3	98928
−1 6	05480	0 4	65542	2 4	99180
−1 5	06681	0 5	69146	2 5	99379
−1 4	08076	0 6	72575	2 6	99534
−1 3	09680	0 7	75804	2 7	99653
−1 2	11507	0 8	78814	2 8	99744
−1 1	13567	0 9	81594	2 9	99813
−1 0	15866			3 0	99865

Fig. 10.5 Probabilities associated with values of z or less under the normal curve.

ability that the total resource cost for the project will be \$23,000 or less is .5; that it will be \$27,000 or less is .90320; and so on. If the project represents something for which a contract price is being negotiated, information of this sort would obviously be very valuable to management.

PERT/Cost

It is also possible to introduce cost considerations into a PERT analysis in another way. For example, it may be possible to reduce the completion time of one or more activities by accelerating the work effort on the activity. However, it is likely that such accelerated effort will require an extra expenditure of cost, such as that required for overtime pay for employees. Thus the benefit from reducing the total completion time of a project by accelerated efforts on certain activities must be balanced against the extra cost of doing so. A related problem is to determine which activities must be accelerated to reduce the total project completion time. This form of analysis is referred to as Critical Path Method (CPM) or PERT/Cost. Though worthy of mention, PERT/Cost will not be illustrated here.[3]

[3] For a presentation of CPM and PERT/Cost, see R. I. Levin and C. A. Kirkpatrick, *Planning and Control with PERT/CPM* (New York: McGraw-Hill Book Company, 1966), or W. R. Ross "PERT/Cost Resource Allocation Procedure," *The Accounting Review*, July 1966, p. 464.

REVIEW QUESTIONS

1. What basic change of emphasis takes place in a systems investigation when work on implementation begins?
2. List several categories of activities commonly performed as part of a systems implementation project.
3. Describe some of the planning and scheduling considerations which are important to systems implementation.
4. Describe in detail the activities in the area of personnel and organizational adjustment that should be performed by a company preparing for computer installation.
5. What steps should a company take to cope with problems of employee morale which may arise when plans to acquire a computer become known to employees?
6. Describe in some detail the major activities in the final systems design phase of preparation for computer installation.
7. Describe several factors which should be taken into account during systems implementation with respect to the establishment of standards and controls for the new system.
8. Describe in some detail the process of preparing a site for the physical location of a computer system in a business organization.
9. Outline and describe the major activities in a company during the conversion phase of computer implementation.
10. Explain what is meant by parallel operation and pilot operation. Compare and contrast these two concepts.
11. What are the major considerations in the decision of how long the period of parallel operations should be? What is the usual length of this period?
12. Describe the process of the follow-up review to a systems investigation.
13. What does the acronym PERT stand for, and to which implementation activity is this technique commonly applied?
14. What do the arrows and nodes in a PERT network signify?
15. What is the critical path in a PERT network?
16. What is a "dummy activity" in a PERT network, and why is it sometimes necessary for networks to contain such activities?
17. Explain how PERT is useful to management planning and control of large complex projects.
18. List four common applications of PERT in business.
19. Explain how cost considerations might be introduced into an analysis using PERT.

DISCUSSION QUESTIONS

20. Modeling techniques such as PERT are often based upon assumptions or estimates which are frequently inaccurate. Discuss the implications of this observation for the usefulness of such techniques.
21. Assume that you are a systems consultant advising a firm's management on implementation of a new computer system. Management has decided not to retain several employees after the system is implemented. Some of these employees have many years of service to the firm. How would you advise management to communicate this decision to its employees?

PROBLEMS AND CASES

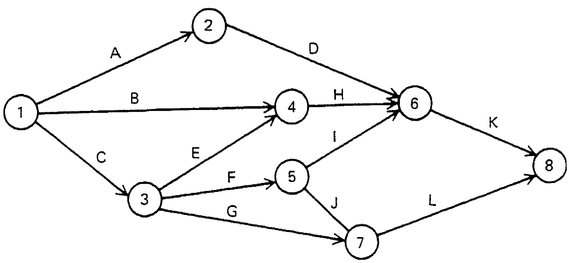
22. Given below are a set of activities, single activity time estimates, and precedence relationships for a project.

Activity	A	B	C	D	E	F	G	H
Activity time	6	3	5	4	3	7	4	6
Predecessors	none	none	B	A,C	A,C	B	D	E,F

Required:

a) Construct a PERT network for this project.
b) Determine the critical path and the total completion time for the project.
c) For each activity, determine the earliest completion time, the latest completion time, and the slack time.

23. Shown below is a PERT network and a related set of activity time estimates.



Activity	A	B	C	D	E	F	G	H	I	J	K	L
Most optimistic time	10	12	8	4	0	12	6	9	4	0	5	9
Most likely time	13	15	11	7	0	18	12	12	6	0	8	12
Most pessimistic time	22	18	20	16	0	36	18	27	8	0	11	33

Required:

a) Determine the expected completion time of each activity.
b) Determine the earliest expected completion time, latest expected completion time, and slack time of each activity.
c) What is the total project completion time, and what activities are on the critical path?
d) Determine the standard deviation of expected completion time for only those activities on the critical path.
e) Determine the standard deviation of expected completion time for the project.
f) Determine the probability that the project will be completed within (1) 41 weeks, (2) 47 weeks, (3) 50 weeks, (4) 59 weeks.

24. Benjamin and Watson Enterprises has decided to acquire a new computer system, and is presently entering a twelve-month implementation period. A schedule of activities for this period follows:

Beginning of:	Activity:
Month 1	A Data Processing Manager-Programmer is hired. He is responsible for final systems design and program flowcharting.
Month 5	A Programmer is hired. The coding process is begun.
Month 6	A Keypunch Operations Supervisor is hired and immediately assumes responsibility for keypunching the programs.
Month 7	Program testing is begun, which requires rental of outside facilities. The rental contract with the company renting the building selected as the computer site is terminated. The remodeling of this site in preparation for installation is begun.
Month 10	Two keypunch operators are hired. The file conversion process begins.
Month 11	Site remodeling, program testing, and file conversion are completed. The computer is installed and two computer operators are hired. Parallel operation begins.
Month 13	Parallel operation is completed and final changeover to the new system is achieved.

The monthly costs attached to these various implementation activities include the following:

Salaries	
Data Processing Manager-Programmer	$1,000
Programmer	800
Keypunch Operations Supervisor	500
Keypunch Operator	400
Computer Operator	500
Overtime during parallel operation	1,000

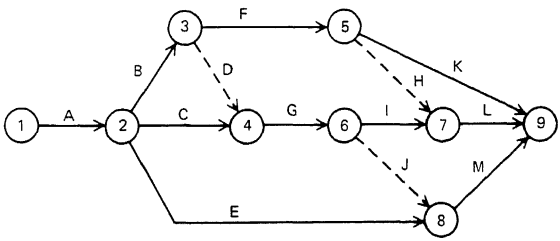
Rental of time for program testing	300
Remodeling of site	800
Computer rental	4,000
Miscellaneous overhead after system is installed	500

In addition, the future site of the computer is presently being rented out at $600 per month.

Required:

Prepare an implementation cost schedule for the twelve-month implementation period. Show each cost as one-line item, and show the total cost incurred during each of the twelve months. Also show the total cumulative cost as of the end of each month.

25. Shaky Construction Company has an opportunity to submit a bid for the construction of a new apartment building. From specifications provided by the developer, a PERT network for the project has been developed, and is shown below. Also shown for each activity are estimates of most optimistic, most likely, and most pessimistic completion times in weeks (a, m, and b, respectively).



Activity	a	m	b	Activity Description
A	5	8	17	Excavate basement.
B	5	8	11	Build concrete elevator tower.
C	3	5	7	Pour concrete foundation.
D	0	0	0	Dummy activity.
E	6	9	18	Excavate parking ramp area.
F	5	8	17	Install temporary manual elevator.
G	5	7	12	Erect main building.
H	0	0	0	Dummy activity.
I	0	0	0	Dummy activity.
J	0	0	0	Dummy activity.
K	4	7	10	Install automatic elevator.
L	7	10	31	Complete interior work.
M	4	6	11	Erect parking ramp.

Required:

a) Compute the expected completion time for all activities in the project.
b) Determine the network critical path and the total expected completion time for the project.
c) Determine the standard deviation of completion time for the project.
d) Shaky's management policy with respect to submitting bids is to bid the minimum amount which will provide a 92% probability of at least breaking even. Materials for this project will cost $900,000 and all other costs will vary at a rate of $10,000 per week for every week spent working on the project. What amount should be bid under this policy?
e) Assume that Shaky's bid was accepted and that the project has been in progress for 20 weeks. Activities A, B, and C have been completed. Activities E, F, and G are in progress, with the following estimates made of time required to complete them:

Activity	*a*	*m*	*b*
E	1	2	3
F	3	5	10
G	3	6	9

No change has been made in the time estimates for activities K, L, and M. Draw a revised PERT network representing the remainder of the project (excluding completed activities). Determine the critical path for the remainder of the project and the remaining project completion time.

Chapter 11

Systems Management and Control

One of the most important concerns in systems design and implementation is the effective operation of the system once the conversion is completed. To accomplish this purpose, it is necessary that the establishment of control policies and procedures for the new system be an integral part of the systems design and implementation process. In addition, a system of post-implementation planning and performance evaluation should be developed during the implementation process and put into effect upon conversion. The success of a newly implemented system is very much dependent upon the strength and effectiveness of managerial planning and control with regard to the system.

Managerial planning for information systems involves decisions about the most advantageous utilization of system resources in the future. These decisions, in turn, affect the requirements of the system for additional hardware, personnel, and financial resources. The need for an effective system of long-range planning is especially critical in large, computerized information systems. The first section of this chapter will discuss this important subject.

Managerial control of information systems incorporates the same general principles of control discussed in Chapter 3. However, the application of these control principles to the large, computerized information system introduces several new concepts and techniques. Feedback control systems for the monitoring of project development, computer operations, and overall system performance constitute the subject of the second section of this chapter. Preventive control policies and techniques designed to reduce the possibility of errors, fraud, or loss of data in computerized information systems are covered in the third section. A final section discusses audit considerations in the design and evaluation of computer systems.

LONG-RANGE PLANNING FOR COMPUTERIZED INFORMATION SYSTEMS

The basic building block of information systems planning is the project development plan. Each such plan is a proposal to develop a particular application for

the computer system. One project plan might call for the development of a production cost reporting system, while another proposes an online order entry system. Responsibility for the identification, selection, and implementation of new computer applications within an organization rests jointly with the systems development staff of analysts and programmers and the system user groups. At any given time, there may be several projects in the process of implementation or in the proposal stage.

The most important single decision made by an organization's management with respect to its information system is the assignment of priorities to the various systems projects under development. This decision defines the future direction of the information system and determines its ultimate success or failure as a profitable tool of management. The great significance of this decision dictates that it must be made at the top management level and that it should not be left to computer specialists. The costs and benefits of each project proposal should be thoroughly analyzed to provide management with a basis for assigning priorities among competing projects. The priority assignment establishes which of these projects deserve a share of the organization's currently available systems development resources.

This section begins with a description of the appropriate content of each project development plan, then explains how the overall long-range systems plan is derived on the basis of the various individual project development plans, and concludes with a discussion of the payoffs of systems planning.

Content of a Project Development Plan

Each project development plan is basically an analysis of the requirements and expectations for a proposed computer application. Requirements are broken down into two categories, developmental and operational. Developmental requirements include all resources necessary to implement the new application. Operational requirements include all resources consumed by regular utilization of the new system subsequent to its implementation.

The resources required for development of a new computer application consist primarily of personnel man-hours. Each new application is really a software system which includes a set of programs and system documentation. The development of such a software system will consume the time of programmers, systems analysts, supervisors, and user group representatives. For each project, the number of man-hours required of personnel within each job classification should be estimated. A timetable should be established which indicates the number of weeks required to complete each step in the development process, and the number of man-hours required for each step. Network planning techniques such as PERT are often used for this purpose.

In addition to personnel man-hours, each development project will also consume some hardware resources. Computer time will be required to test and debug individual programs as they are written. As the project nears completion, the system as a whole must be tested and operators trained in its usage. If the

system is to replace an existing system, parallel operation will be necessary. The computer time requirements for all of these activities should be specified with respect to the amount of time required and the timetable for utilizing that time.

An estimate of the financial resources needed for development of each application can be derived from the analysis of personnel, hardware, and other miscellaneous requirements such as supplies. These will consist primarily of personnel salaries and hardware utilization costs. All of the cost outflows should be classified into time periods to produce a project budget. The total of all of these costs, discounted if the time factor is significant, represents the total financial investment in the project.

The operational requirements of a computer application include the hardware time required for processing, the time of machine operators required to prepare input data and monitor the operation of the computer and other equipment, the time of programmers and analysts required to maintain the software system, and the supervisory time required for all of these activities. The project development plan should include a conversion of these requirements into financial terms. The operating cost estimate should be stated on a "per week" or "per month" basis.

Finally, each project development plan should include an analysis of the expected economic benefits of the new application. This analysis is essential to management's determination of priorities for proposed projects, as well as to the establishment of responsibility for the success of the project. Few general guidelines can be specified for this analysis, but one essential rule is that the users who will receive the benefits of a computer application must be involved in the estimation of its economic utility.

Content of the Overall Systems Plan

The individual project development plans form the basis for the overall long-range systems plan of an organization. The heart of the long-range systems plan is a projection of future requirements for all categories of resources, including personnel, hardware, and funds, made for each month within the next three to five years. This projection represents the sum total of: the operational requirements for presently operating applications; the operational requirements for applications presently under development which are scheduled to be completed during this period; and the developmental requirements for all projects which are presently under development or scheduled to begin development within the period. Operational requirements for presently operating applications can be derived from estimates of the growth in their current requirements. All other projected requirements are derived by summing the requirements of all project development plans to obtain totals for each resource category for each month of the period.

The requirements projection provides a basis for specific resource planning by management. A comparison of projected hardware capacity requirements

with present hardware capacity enables management to develop an optimum hardware acquisition plan. The time at which acquisition of specific hardware units will be necessary can be determined, and the appropriate time for upgrading to a completely new hardware system can be pinpointed. Similarly, a comparison of present personnel levels with projected personnel requirements facilitates management planning of hiring and training programs. Projected financial requirements can also be derived from the requirements projection and utilized for budgeting purposes.

Advantages of Systems Planning

An effective program of long-range planning for its computer-based information systems pays dividends to an organization in several ways. Most importantly, it provides a sound basis for selection of new computer applications. The alternative to long-range planning is to decide upon each proposal as it is made, independently of other proposals. Since all development projects consume the limited financial and personnel resources of the organization, it is essential that each of the potentially profitable computer applications be subjected to comparative scrutiny for identification and ranking according to their expected profitability rather than be considered separately. Only in this way can management maximize the return on its investment in computer systems.

A second advantage of systems planning is that it enables an organization's computer effort to be coordinated with its overall long-range planning program. This is important because the information system is only one of several competing uses of organizational resources. The systems plan provides a better basis for deciding what portion of available corporate resources should be allocated to the information systems function. Furthermore, as the goals and strategies of the organization are revised, it may become necessary to revise the priorities of the various project development plans.

Long-range systems planning also enables better coordination among the various information subsystems within the total system. It allows management to anticipate needs for increased systems capacity and thus avoid situations of insufficient capacity. It also permits management to plan for the most effective utilization of new technological developments. Finally, it provides a basis for management control of the systems development effort, a subject which is explored at length in the next section.

MANAGEMENT CONTROL OF COMPUTERIZED INFORMATION SYSTEMS

The principles of feedback control systems may be applied to three elements of a computer-based information system: the project development effort, the computer operations function, and the total data processing service function. The primary objectives are to control the costs of the information systems function and assure the achievement of anticipated benefits from that function. Feed-

back control policies and procedures in each of the three areas are discussed in this section.

Control of Project Development

As mentioned in the previous section, the long-range systems plan provides a basis for management control of project development. Each project under development within an organization should be subject to periodic progress reviews. These progress reviews should ascertain whether each project is being completed within its scheduled developmental timetable. In addition, the adherence of the project team to quality standards for documentation, program testing, and system auditability should be assessed. Any significant deviation of a project from its timetable or from quality standards calls for management action to rectify the problem. If the control problem for a project is so serious that management is unable to correct it, the entire project timetable should be revised and the project's priority reassessed.

Management control of systems development also requires an evaluation of the individual systems analysts and programmers involved in that activity. Because this work is primarily creative in nature, it is difficult to establish performance standards and measurement techniques. However, it is essential that information be collected on the activities engaged in by each analyst and programmer. A time reporting system should be used in which each such employee is required to account daily for how his time was spent, with his activities classified according to the projects and programs worked on and the type of work performed. Such a reporting system provides input for both project cost reporting and analyst and programmer performance evaluation.

With respect to programming, it is possible to develop rough measures of accomplishment for comparative purposes. The number of instructions which a completed program contains may be divided by the number of hours spent by the programmer in preparing the program to provide a measure of "instructions per hour." This measure may then be used to compare the relative efficiency of all programmers within the organization. Further provisions have to be made to take into account factors such as the differences in size and complexity of programs and the variations in experience levels of programmers. Nonetheless, this approach in its simplest form does at least furnish some objective information with which to control programming activities, and it also provides a basis for estimating the time and cost requirements of future developmental projects.

Another important aspect of project control is the follow-up review subsequent to implementation of a new computer application. This should be done periodically for all applications for the purpose of evaluating whether each is generating economic benefits in excess of costs in an amount consistent with the original project proposal and development plan. Any significant unfavorable variance should require an explanation from the persons responsible for the original estimates and should initiate efforts to correct the situation if

possible. In extreme cases, it may be necessary to scrap the application altogether. These follow-up reviews not only help to control project development activities, but also to encourage more accurate and objective initial estimates of project costs and benefits.

Control of Computer Operations

A basic element of computer operations control is the processing schedule. The schedule assigns each data processing operation to an appropriate time period for every day that the system is to be utilized. The schedule must allow adequate time for the completion of each operation, and should represent an attempt to maximize the productive utilization of all items of equipment. The schedule should also provide time for necessary preventive maintenance and should allow some slack time for the inevitable equipment malfunctions requiring corrective maintenance and for occasional reruns of incorrectly processed work.

Evaluation of the performance of all machine operators should be based upon a comparison of actual processing time with scheduled processing time for all jobs run by each operator. Of course, actual processing time must be adjusted for losses of productive time due to malfunctions or other factors not under the control of the operator. Furthermore, the scheduled processing time must be adjusted for variations in actual volume of processing from average volume to provide an equitable standard.

The performance of input preparation personnel may be evaluated in two ways. One is by measuring their output in terms of keystrokes per hour or some similar measure and then comparing each individual operator's rate to an average or standard. A second is to measure the error rate of all input preparation work in terms of the percentage of errors discovered by key verification or by editing routines built into the computer programs. Obviously, these two approaches complement each other, since one is basically a measure of efficiency and the other of quality.

Also useful for computer operations control is information on machine utilization for each computer. The data necessary to generate this information should be recorded in a computer log by each operator. The log should account for the utilization of all available computer time for either productive work, preventive maintenance, corrective maintenance, reruns, or idle time. Productive work should be further classified according to the specific application or development project for purposes of accumulating cost data on existing applications and applications under development. Each week or month, a report should be prepared for the operations manager showing the actual and percentage breakdown of total available computer time into each of the possible categories. This report is useful for establishing operating policies, evaluating departmental performance, scheduling operations, and estimating operating costs for new projects.

Control of the Total Information Service Function

Since the information systems function is typically a separate organizational unit, responsibility accounting techniques may be utilized for management control purposes. The systems function may be treated as a cost center, a profit center, or an investment center.

If the information system is treated as a cost center, the data processing manager is allocated a fixed budget intended to cover all costs of providing information services. His performance is then evaluated according to whether actual costs fall within or exceed the budget. This approach has the advantage of reducing the possibility of substantial cost overruns in the information systems function, and it is also simple and should be familiar to management. However, in most cases it is inappropriate to apply this method to the systems function, since increases in expenditures on this function should, if properly controlled, produce even greater increases in economic benefits. Furthermore, since the information system provides a service function, a fixed budget may limit available services to a level much smaller than the level of demand of user departments.

Treating the information system as a profit center or an investment center requires that a transfer pricing mechanism for computer services be established. The unit measure for equipment utilization may be machine hours or volume of input and output, while for systems development services, it is simply hours worked. The unit price may be based upon cost, negotiated with users, or upon market rates. The data processing manager is evaluated on the basis of net profit or return on investment. The basic advantage of an approach of this type is that it enables an equilibrium to be achieved between available capacity and user demand. If user demand exceeds capacity, the profits generated by the operation are invested to increase its capacity. This approach also fixes the 2.
responsibility for evaluating new computer applications where it belongs — with the users who will receive the benefits. As a result, the post-implementation 3.
review function also becomes the responsibility of the individual user departments.

The profit and investment center approaches also have disadvantages. First, the determination of an appropriate transfer price for internal services is an issue which inevitably creates friction within an organization. Second, if information services are highly priced, the effect may be to discourage the development of potentially profitable new applications, especially those for which benefits are intangible. Despite these disadvantages, either the profit center or investment center approach is probably superior to the cost center approach for most organizations.

PREVENTIVE CONTROLS IN COMPUTERIZED INFORMATION SYSTEMS

The objectives of preventive controls in computerized information systems include: prevention of errors in processing caused by operators, program bugs,

or inaccurate input; prevention of embezzlement; prevention of damage to equipment or loss of vital business data caused by hardware malfunctions, sabotage, riots, or natural disasters such as fire or flood; and easy auditability of the information system. This section discusses general control standards and policies in computer installations and then describes several specific system controls over the flow of data through the computer system.

General Standards and Policies

Certain control standards and policies apply generally to the entire information systems function. These include separation of functions, documentation standards, protection of facilities, data security, insurance, and controls over errors and exceptions. Each of these areas is discussed in turn.

Separation of functions. Organizational independence in a computerized information system is quite effectively achieved if there is a clear division of authority and responsibility among the functions of: systems analysis and programming, computer operation, input preparation, tape library, and data control. As mentioned in Chapter 2 the most important separation is that between analysts and programming personnel on the one hand and operations personnel on the other. Such a separation should be maintained to prevent analysts and programmers from manipulating programs to accomplish fraudulent ends. Without access to equipment or to tapes containing programs and files, a programmer could not easily carry out any unauthorized scheme.

Separation of the analysis and programming function from other functions should be accompanied by a policy of formal authorization for necessary program changes. A written description of such changes and the reasons for them should be submitted to the data processing manager, chief analyst, or some other person in a position of authority. His authorization should be required prior to testing such changes, and his approval of test results should be required prior to final implementation of program changes. Complete documentation of all program changes should be retained.

Separation of the computer operations function from other functions is also important. The access of operations personnel to program documentation should be limited to only that which is necessary to perform the equipment operations function. This prevents an operator from learning enough about a program to make any unauthorized changes. Separation of the operations function and tape library function prevents the usage of programs and files except at times authorized under the regular processing schedule. Another form of control over computer operations is relatively close supervision, or perhaps a policy requiring two qualified employees to be on duty in the computer room during all processing. In addition, a copy of the printout from the computer console should be maintained as a record of processing. This console log should be periodically reviewed for any evidence of irregularity in connection with manual intervention by the operator during regular processing.

In larger installations which can afford a greater degree of specialization, a separate data control function provides an additional element of organizational independence. This function is responsible for monitoring the flow of input and output between the computer room, input preparation, and external departments. Data control involves such activities as: reviewing externally supplied input for correctness of content, maintaining a log of all work in process, establishing control totals and checking them at each step in processing, and following up on errors identified by computer editing and validation programs. Maintaining data control function as a separate entity provides better supervision of and control over computer operations and facilitates more efficient processing.

Documentation standards. Good documentation is an important asset to the efficient operation and control of an electronic data processing system. Management must establish and enforce standards which specify what documentation is required for projects under development and for fully implemented systems. A suggested list of elements of documentation for a computer application is presented in Chapter 6. Management should be assured that adequate documentation is being prepared for all projects under development as part of the regular progress review process. Management must impress upon all systems development personnel the importance of documenting their work. Management is also responsible for maintaining system documentation in up-to-date form for all operational computer applications.

The purposes served by well-planned and enforced documentation standards within an organization are many. Among the benefits resulting from good documentation are: facilitation of communication among system users, analysts, and programmers during systems development; facilitation of regular progress reviews of systems development work; provision of a reference and training tool for system users, machine operators, and newly hired employees within the systems function; and simplification of the program maintenance function.

Good documentation is particularly important in view of the high rate of turnover among systems analysts and programmers. If a programmer leaves an organization in the middle of a major project, much time may be wasted by his colleagues in attempting to continue his work if he has not maintained up-to-date documentation. If a programmer responsible for developing some of the existing applications in a system leaves without having provided adequate documentation, the making of necessary changes in those applications may be extremely difficult, perhaps almost as difficult as developing completely new programs. These potential problems underscore the necessity of requiring analysts and programmers to adhere to documentation standards in their work.

Protection of facilities. An organization's investment in computer facilities often amounts to hundreds of thousands or millions of dollars. It follows that this equipment should receive adequate physical protection. Access to the computer system itself and to all online data terminals should be restricted at all times to authorized personnel only. The temptation to locate the computer

facilities in a glass-encased "showcase" should be avoided, for this presents an inviting target for ill-intentioned persons. Contingency plans for protection of equipment during natural disasters or riots should be established.

Data Security. Good internal control in a computer installation requires that provisions be made for protection of files and programs from loss or accidental destruction. As mentioned previously, a tape library from which tapes or disk packs may only be taken for authorized purposes is one essential element of such control. Both the computer room and file storage locations should be protected against fire, dust, excesses of heat or humidity, or other adverse conditions.

Tape rings and file labels are useful devices in protecting against accidental writing over or erasure of files. A *tape file protection ring* is a device which, when inserted on a reel of magnetic tape, permits writing on the tape. In the absence of the ring, the tape may not be written on, and the data on the reel is protected. Thus the tape ring is removed when any application is processed for which the tape file need only be read. File labels are both internal and external. An external label may be merely a gummed paper label attached to a tape reel or disk pack. Internal file labels are the first and last records in a tape or random access file. The first record, or *header label,* is read by the computer prior to processing and checked against the program to assure that the tape is the correct one for the program. The last record, or *trailer label,* indicates the end of the file and may contain control totals for checking against those accumulated during processing.

In addition to protection against loss or destruction, an information systems control plan should also make provisions for reconstruction of records should such loss actually occur. Duplicate tapes of programs and important files should be stored in a location away from the computer facility as a protection against a major disaster such as fire or flood. One data retention procedure used most commonly with magnetic tape files is known as the *grandfather-father-son concept.* Under this plan the three most recent master files are all retained, with the "son" file being the most recent. If the processing to produce the "son" file from the "father" file is accomplished with no errors or destruction of records, the "grandfather" file is then no longer needed and can be reused as the new "son" file at the next file update. If an error or loss of records does occur in the "father" and/or the "son" file during processing, the "grandfather" file can be used as a basis for reconstruction.

With respect to disk files, a file security program requires that the contents of the file be duplicated, generally by writing the file onto magnetic tape. If transactions are processed in batches, the duplicate serves as the "father" file in the event of errors or destruction of data in the updating process. If transactions are processed online, a log of all transactions may also be recorded on disk or tape which, together with the most recent duplicate copy of the file, could be used to reconstruct the current disk file.

With respect to highly confidential data, a system of cryptographic protection for data storage and data transmission may be used which involves translating the data into a secret code. This approach assumes particular importance where confidential data is being transmitted from remote terminals, since data transmission lines can be electronically monitored without the user's knowledge.

Insurance. In addition to physical protection of facilities and data security procedures, an insurance program is an essential control device. Major risks to be insured against include fire, flooding, severe weather, riots, and sabotage. The fidelity bond (see Chapter 3) provides insurance against the risk of loss from embezzlement. Fidelity bonds are particularly essential in small installations where extensive separation of functions is not possible. In some installations which handle work for outsiders in addition to their own work, liability insurance for losses incurred due to errors in performing the work may be necessary.

Backup systems. Also of major significance in preventing losses due to system malfunctions or natural disasters is a system of backup facilities or procedures. For example, a contract could be made which permits usage of the facilities of the vendor or a service bureau in the event of an emergency. In some cases, hardware failures in system components can be isolated, enabling the remainder of the hardware system to continue operation, though in a less efficient mode, until the malfunctioning component is fixed. This is referred to as *graceful degradation.* In a real-time system for which maintaining a constant level of service is essential, some hardware components may be duplicated in order that the system can switch to the backup component if necessary. The duplex system (see Chapter 7) is an example in which the CPU itself is duplicated, but it is also possible to duplicate other components, such as terminals or multiplexors. In all real-time systems, some sort of manual bypass procedures should be devised to cope with the possibility of a system failure which shuts off service altogether.

Control over errors and exceptions. Another essential element of control in a computer installation is the set of procedures for correction of errors and investigation of exceptions. If a data control section exists, this function is usually one of their responsibilities. Error reports may be produced as the output of special validation routines or of the file updating process itself. Procedures for correction and reentry of erroneous input should be prescribed, and data control personnel are responsible for making sure that such procedures are carried out accurately. Corrected input should again be submitted to validation routines, for the error rate on error corrections is perhaps higher than on any other type of transaction. Exceptions encountered during processing, such as transaction amounts or file balances which exceed prescribed limits, should be investigated to reveal their cause. The control group is also responsible for investigating and correcting the cause of any discrepancy in comparisons of control totals.

System Controls over Input and Output

Input-output controls are those controls over data accuracy which are accomplished externally to the machine processing itself. They include batch totals, source data controls, sequentially prenumbered forms, and turnaround documents.

Batch totals. Batch totals are as essential to computerized batch processing as they are to manual data processing. In a computerized batch processing application, batch totals are accumulated manually from source documents prior to input preparation. The original totals are then compared to machine generated totals at each subsequent processing step. Any discrepancy may indicate a loss of records or error in data transcription or processing.

Three forms of batch totals commonly used in computer systems are *financial totals, hash totals,* and *record counts.* A financial total is simply the total of a dollar field in a set of records, such as total sales or total cash receipts. A hash total is a total generated from a field which would usually not otherwise be added, such as a total of all customer account numbers or employee identification numbers. A record count is a total of the number of input documents to a process or of records processed in a run.

Source data controls. One form of checking the accuracy of input data is key verification, which may be done with a card verifier (see Chapter 4) or a key to tape recorder (see Chapter 5). Where key verification is not considered to be essential or is too expensive, a substitute source data control is the visual inspection of printed listings of input prior to processing.

Another source data control is *check digit verification,* which is performed by an input device such as a keypunch or cash register with paper tape punch. In check digit verification, all authorized identification numbers contain a redundant digit, called the check digit. This digit is a numerical function of the other digits in the number. For example, in the number 90614, the last digit, 4, could be generated by subtracting the sum of the first four digits from the next highest number ending in zero (20 - 16 = 4). The number 41365 would fail this test. If an error in the recording of a data item occurs, check digit verification will likely (but not certainly) catch the error so that a correction can be made prior to submission for processing.

Sequentially prenumbered forms. As is the case in manual systems, sequentially prenumbered forms provide a useful form of control over source documents to computer systems. In a computer system, control of sequentially prenumbered forms is faciliated by using the computer to determine and report the numbers of forms which have not been processed. The forms containing these numbers can then be traced in order to assure that all data which should be processed is eventually received by the system.

Turnaround documents. The turnaround document is defined in Chapter 4 and described as a means of reducing the data preparation workload. Since turnaround documents are automatically prepared as computer output, the data

One other form of edit check is the *redundant data check*. This check requires that two identifiers be included for each input transaction record which is to be updated in order to confirm that the correct match will be obtained by cross-checking. For example, if both the customer account number and the first five letters of the customer's name are included on the input record, the system can check, after obtaining a match on account number, whether the first five letters also match those on the file. This check has the purpose of preventing the posting of transactions to the wrong master file records.

Online data entry controls. This category includes all controls over the accuracy and integrity of input data and inquiries entered into the system from online data terminals. Most controls in this category are specialized forms of input validation routines which are unique to online systems. In addition, many of the edit checks described in the previous section are useful in online systems as well as in batch systems. These include field checks, validity checks, limit checks, reasonableness tests, and the redundant data check.

One essential online data entry control is a user code system. Under such a system, each authorized user is assigned a unique user code which he must key into the system prior to using it. If the user cannot supply an authorized code number, the system shuts off service to his terminal. Once an authorized code number has been accepted by the system and the user is allowed to proceed, the system may apply a *compatibility test* to transactions or inquiries entered by the user. This checks whether the user having the code number given is authorized to initiate the type of transaction or inquiry he is entering. For example, factory employees would not be authorized to make entries involving accounts payable. This helps to prevent both unintentional errors and deliberate attempts to manipulate the system.

One form of edit check which is very useful in an online system in which terminal operators are inexpert is a *completeness test*. This is simply a check that all required input data for a particular transaction has in fact been entered by the terminal operator. If the system detects inaccurate input according to this or other edit checks, a message is printed on the terminal requesting that the operator reenter the item in question.

After all data for a transaction have been entered by a terminal operator, the system can transmit all or some of the data back to the terminal so that the operator can confirm its accuracy. This *closed loop verification* controls the accuracy of data transmission. For example, the system might send back the message number and a bit count. The operator could verify that the bit count was equal to the bit count computed by the terminal prior to the transmission. If they are not equal, he retransmits the message. If they are equal, he indicates this and the system then proceeds to process the transaction. Closed loop verification may also be used to check whether the correct item number or account number has been entered. For example, if the operator enters an inventory part number, the system could print out the item description from the file. The

operator could then confirm that this was indeed the item to which he intended to refer.

In remote batch processing systems, where several transactions are being entered in a batch, it is useful for the terminal operator to number each transaction sequentially. In this way if a system malfunction occurs which temporarily shuts down the system, the number of the last transaction processed can be provided to the operator by the system once service is restored. This helps to assure that no transactions are lost, or that none are inadvertently entered twice, as a result of a system malfunction.

Programmed controls over processing. In addition to edit checks, there are several other control routines which can be programmed into each data processing application. One example is the *cross-footing balance test*, in which the sums of vertically accumulated columns of data are compared to check the accuracy of calculations. For example, the sum of the gross pay column in a payroll application should equal the sum of the net pay column plus all deductions columns. Another example of programmed controls are *overflow procedures*, which are routines for recording and reporting the arithmetic calculation of a number which exceeds the capacity of the computer's accumulator or of the area reserved for the result.

Hardware controls. Several control features are built into the hardware in a computer system. One example is *duplicate circuitry* in the arithmetic unit of the central processor which results in duplicate performance of computations and subsequent comparison of the two results. *Dual reading* is another hardware control in which records on cards, tape, or random access media are read twice by separate reading components, and the results of both read operations compared. Still another hardware control is the *echo check*, in which the accuracy of data transmission to an output device is checked by comparing a signal sent back to the computer from the output device with the data originally sent.

The use of the parity bit to check the accuracy of data transfer within a computer system is one type of hardware control which has already been discussed (see Chapter 5). Two-dimensional parity checking is an extension of parity checking commonly used for data transmission over telecommunication facilities. This involves use of a redundant column of check bits for each record in addition to a redundant row of check bits. The parity checking is thus done both vertically and horizontally. This form of control is important in telecommunications because noise bursts frequently cause two or more adjacent bits to be lost or picked up. A vertical parity check alone would not catch many such errors.

Two additional hardware controls which help to prevent processing errors are *preventive maintenance* and *uninterruptible power systems*. Preventive maintenance involves regular testing of all system components and replacement of those found to be in a weak condition. This greatly reduces the likelihood of a system failure during regular operations. An uninterruptible power system

consists of an auxiliary power supply which operates as a buffer between the power input from the electric company and the power usage by the computer. Such systems smooth out the flow of power to the computer, eliminating loss of data which might be caused by momentary surges or dips in power flow. In the event of complete power failure, uninterruptible power systems provide a backup power supply to keep the computer operating without interruption until regular power is restored.

AUDIT CONSIDERATIONS IN COMPUTERIZED INFORMATION SYSTEMS

Both the internal and external auditor are concerned that the control standards and procedures described thus far in this chapter are in effect in a computer data processing system. In addition, the auditor will wish to test the reliability of the system in processing various types of transactions. The auditor's evaluation of the sufficiency of internal control procedures will affect his determination of the extent of testing necessary to satisfy him concerning the reliability of the system.

The advent of electronic data processing has had a major effect upon auditing, due primarily to the loss of a visible audit trail in computerized systems. More specifically, computerized data processing systems maintain files on media that is machine readable, such as magnetic tape or disk. File content may be printed out infrequently or at irregular intervals. A history of the activity relating to each individual file is not maintained. In online processing, even a printed record of input may not be produced.

The importance of internal control and the natural tendency toward elimination of visible audit trails in computerized information systems underscore the need to involve the auditor in the systems design process. While good system controls do not eliminate the need for a periodic audit, they do significantly reduce the extent of testing necessary to the audit.

The first reaction of auditors to the use of computers in data processing was to attempt to perform their audits with the printed records and output provided by the system, ignoring the computer and its programs. This approach was referred to as auditing "around" the computer. The assumption underlying this approach was that if a sample of system output was correctly obtained from system input, then the processing itself must be reliable. This was a reasonable approach ten or fifteen years ago when the knowledge of electronic data processing among auditors was limited. However, the increasing difficulty of applying this approach to a disappearing audit trail, and the development of better methods of auditing computer systems have combined to discredit the old approach of auditing "around" the computer.

The alternative to auditing "around" is referred to as auditing "through" the computer. This approach uses the computer itself to check the adequacy of system controls. Two approaches to auditing "through" the computer are the use of test decks containing sample transactions and the use of specially written computer programs.

The use of sample data to test the functioning of a program and its related control procedures is the same process that a programmer goes through in testing and debugging a program prior to its implementation (see Chapter 6). The auditor must develop a clear understanding of the nature and function of each program tested. This is another reason that good documentation should be available in an information system. Care should be taken to develop a set of test data that will test each program's response to all possible errors and exceptional conditions. The auditor will wish to learn what controls are contained in each program and while he should specifically test these controls, he should not restrict himself to testing only the existing controls.

The auditor may run test data against dummy master files or against the live current master file. If a dummy master file is used, the auditor himself is responsible for following up on exceptions and recommending necessary changes. If test data is processed as part of regular updating of live files, the auditor has the opportunity to observe the response of system personnel to the errors and exceptions. In this way he can obtain some assurance that proper procedures are being followed to correct all errors and resolve all exceptions encountered in processing. Under this latter approach, care must be taken to assure that live records do not become contaminated by the errors contained in the test data.

Another approach to auditing "through" the computer which is becoming increasingly popular is the use of specially written computer programs. Such programs are used to process master files and thus assist the auditor in performing a variety of audit tasks relating to each file. For example, the items in a file might be classified into categories which would permit application of separate audit procedures to each category. A random sample of items in the file might be selected for testing by the auditor. The program might stratify the records in the file according to the size of the dollar balance of each; the auditor could then investigate in detail all records with balances in excess of a specified amount. The program might be used to accumulate the numerical total of any or all fields in the file so that the auditor could check the total against externally maintained control totals. Exceptional cases or items failing to meet certain criteria can be listed for review by the auditor. Use of the computer to perform these various tasks relieves the auditor of a great deal of time-consuming and detailed work.

REVIEW QUESTIONS

1. Define the following terms:

tape file protection ring	limit check
header label	reasonableness test
trailer label	compatibility test
grandfather-father-son concept	completeness test
graceful degradation	redundant data check

financial total
hash total
record count
check digit verification
edit check
sequence check
field check
sign check
validity check
closed loop verification
cross-footing balance test
overflow procedures
duplicate circuitry
dual reading
echo check
preventive maintenance
uninterruptible power systems

2. Explain in general terms how an organization's management can help to assure the success of a newly implemented information system.
3. Explain why the assignment of priorities to proposed new computer applications is a very critical decision for an organization's management.
4. Describe in some detail the content of a project development plan.
5. Describe in some detail the content of an overall information systems plan for an organization.
6. Explain several advantages of long-range planning for information systems.
7. Describe how management control of project development activities should be maintained.
8. Describe several elements of a program of management control of computer operations.
9. Describe both the cost center and profit center approaches to management control of the information systems function. Explain their relative advantages and disadvantages.
10. What are the objectives of preventive controls in a computerized information system?
11. What functions in a computer system should be organizationally independent and why?
12. What procedures should be utilized in a computer system to control program changes?
13. What are the functions of a data control section in a computer system?
14. What reasons exist for maintaining up-to-date documentation in a computer system?
15. What provisions should be made in a computer system to protect files, programs, and equipment from loss or destruction? What provisions for reconstruction of records in the event of loss should be made?
16. What forms of insurance should be maintained as part of the control plan for a computer installation?

17. Describe several approaches to the use of backup facilities or procedures for prevention of losses due to system malfunctions or natural disasters.
18. What procedures should be established for control over errors and exceptions in a computerized information system?
19. What type of errors are batch totals intended to reveal? Describe three basic types of batch totals and give an example of each.
20. Describe three types of source data controls.
21. How can a computer system facilitate the use of sequentially prenumbered forms for control purposes?
22. How does the use of turnaround documents contribute to internal control in computer systems?
23. Distinguish between input-output controls and processing controls.
24. What is an input validation routine? Describe several edit checks that might be included in such a routine, and give an example of each.
25. What are online data entry controls? Describe several examples and explain how each might be utilized.
26. List several edit checks which are equally useful in both batch and online processing systems.
27. Describe two categories of programmed controls over computer data processing and give an example of each.
28. Describe several types of computer hardware controls.
29. What effect will an auditor's evaluation of control procedures in a computer system have upon the extent of his tests of the system?
30. Why is it said that the audit trail has disappeared in computerized data processing systems?
31. Distinguish between auditing "around" and auditing "through" the computer. Describe two approaches to auditing "through."

DISCUSSION QUESTIONS

32. The approach to long-range information systems planning described in this chapter is obviously important for large organizations having extensive investments in computer facilities. Should small organizations, in which the computer department employs less than, say, 10 persons attempt to implement such planning programs? Discuss.
33. Many persons believe that programming is basically a creative activity, and should therefore not be subject to cost controls and other managerial regulation. Discuss this point of view.

34. A computer implementation project is often performed in a state of crisis, with the implementation group working feverishly to keep pace with the implementation schedule. In this atmosphere, corners are often cut with respect to documentation and programmed controls. What arguments do you feel would be effective to prevent such cutting of corners, even though doing so could delay implementation?

35. Theoretically a control procedure should be adopted if its benefit value exceeds its cost. How can the benefit value and cost of the following controls be estimated?

    a) separation of functions
    b) data security provisions
    c) turnaround documents
    d) input validation routines

36. How much must an auditor know about computerized information processing in order to adequately perform his function within an organization utilizing computers extensively in its information system?

PROBLEMS AND CASES

37. What control or controls would you recommend in a computer system to prevent the following situations from occurring?

    a) The "time worked" field for salaried employees is supposed to contain a "1" for one week. For one employee, this field contained the number 40 and a check for $6,872.51 was accidently prepared and mailed to this employee.
    b) A programmer obtained the master payroll file tape, mounted it on a tape drive, and changed his own monthly salary from $800 to $1,200 through the computer console.
    c) A bank programmer wrote a special routine, punched a set of cards for the routine, obtained the program which calculates interest on customer accounts, and processed the cards against the program to add the routine to the program tape. The routine adds the fraction of a cent of each customer's interest, which would otherwise be rounded off, to his own account.
    d) The master accounts receivable file on disk was inadvertently destroyed and could not be reconstructed after being substituted for the accounts payable file in a processing run.
    e) Loss of almost all of its vital business data from a fire which destroyed the room in which a company stored its magnetic tape files.
    f) A programmer quit the firm in the middle of a programming assignment. Because no other programmers could make sense of the work he had completed, the project was begun over from scratch.
    g) A salesman keying in a customer order from a remote terminal entered an incorrect stock number. As a result, an order for 50 typewriters was placed for a customer who had intended to order 50 typewriter ribbons.

h) A janitor cleaning out the drive-in booths of a bank entered a $1,000 credit to his own account over an online terminal.
i) A salesman provided with a terminal with which to enter customer orders used it to initiate a $500 increase in his own monthly salary.
j) A salesman keying in a customer order from a remote terminal inadvertently omitted the delivery address from one order.
k) A company's research and development center utilized remote terminals tied into its computer center 100 miles away. By utilizing a wiretap, the company's largest competitor was able to steal secret plans for a major product innovation.
l) Because of failure in a $400 multiplexor serving terminals at eight drive-in windows, a bank was forced to shut down the windows for two hours during a busy Friday afternoon.
m) A twenty-minute power failure which shut down a firm's computer system resulted in loss of data for several transactions which were being entered into the system from remote terminals.
n) During payroll processing, an error correction entry performed by the console operator resulted in the unintentional recording of data on the payroll master tape file, which destroyed several records on that file.
o) During keypunching of customer payment records, the digit "0" in a payment of $123.40 was mistakenly punched as the letter "O." As a result, the transaction was not correctly processed and the customer received an incorrect statement of account.
p) After updating the inventory master file maintained on magnetic tape, the old master tape was removed for use in other applications. The updated master was then accidently mislabeled and its contents subsequently erased. Considerable difficulty was encountered in reconstructing the master inventory file.

38. The Ryan Corporation is implementing a system of cost control for systems analysis and programming activities. All programs under development are to be assigned a five digit code, with the first two digits representing the project of which the program is part. The types of activities performed by analysts and programmers include: analysis, design and flowcharting, coding, testing and debugging, conversion, documentation, program maintenance, meetings, and time off.

Required:

Design a daily time sheet which the Ryan Corporation can use to collect data for both project control and analyst-programmer performance analysis.

39. Check digit verification schemes apply a series of mathematical operations to the first $n-1$ digits of an n digit number to determine the correct value of the nth digit. Assume that check digit verification is to be applied to a five-digit number. One check digit scheme, called the "simple sum" method,

would determine the sum of the first four digits and subtract that sum from the next highest multiple of ten to obtain the check digit. Another scheme, called the "2-1-2" method, would compute a weighted average sum of the four digits, with first and third digits from the right weighted by a factor of 2, and the second and fourth digits from the right weighted by a factor of 1. The sum is also subtracted from the next highest multiple of ten to obtain the check digit.

Listed below are two columns of five-digit numbers. All six of the numbers in the left-hand column are valid according to both check digit methods described above. (You might want to verify this.) The numbers in the right-hand column are erroneous versions of their column counterparts. The first two contain single transcription errors, in which one digit has been copied incorrectly. The second two contain transposition errors, in which two digits have been transposed. The third two in the right-hand column are completely garbled.

14267	14567
23573	28573
32582	35282
43274	43724
50609	36609
92487	65937

Required:

a) Determine which of the numbers in the right-hand column would fail check digit verification under (1) the simple sum method, and (2) the "2-1-2" method.

b) Based upon the results of part (a), can you form any conclusions about the relative effectiveness of the two check digit methods?

40. Consider the following set of numeric computer input data:

Employee number Col. 1-3	Payrate Col. 4-6	Hours worked Col. 7-8	Gross pay Col. 9-13	Deductions Col. 14-18	Net pay Col. 19-23
121	250	38	$9500	01050	08450
123	275	40	11000	01250	09750
125	200	90	16000	02000	12000
122	280	40	11200	11000	00200

Required:

a) From the above data calculate one example of the following: hash total; record count; financial total.

b) For each of the controls listed below, give a specific example from the four records above of an error or probable error which would be caught by the control:

field check	reasonableness test
sequence check	crossfooting balance test
limit check	

41. The Dooley Company operates its Data Processing Center as a cost center. Each year a budget for the center is developed by the company's Controller and the Manager of the Data Processing Center. The Manager's performance is evaluated on the basis of a comparison of actual costs incurred to budgeted costs.

    The Manager of the Data Processing Center is responsible for accepting or rejecting proposals from user departments for new applications. User departments are not charged for either programming work or data processing service.

    Some of the main problems relating to the operation of the Center have been:

    1) The Manager has complained that his budget allowances are not sufficient to pay for necessary new equipment and personnel.
    2) There is frequent uncertainty and disagreement regarding decisions on whether proposed new applications should be undertaken.
    3) The Accounting, Production, and Marketing Departments have frequently disputed over whose applications should obtain priority in development and scheduling.

    Required:

    a) Identify the policy or policies which are the probable cause of each of the problems cited above. Explain.
    b) Describe an alternative system of management control which might be appropriate for the Data Processing Center. Explain how this approach would be implemented and how it might contribute to solution of the above problems.

42. The Perry Corporation has four new computer applications under development or scheduled to begin development shortly. The monthly requirements of these development projects for computer time and for system analyst-programmer time over the next two years are indicated on the following page.

	Project A		Project B	
Months	System hours	Analyst - programmer hours	System hours	Analyst - programmer hours
1-6	20	240	30	352
7-12	75	380	30	400
13-18	80	100	100	550
19-24	88	110	150	120

	Project C		Project D	
Months	System hours	Analyst - programmer hours	System hours	Analyst - programmer hours
1-6	25	264	---	---
7-12	30	280	---	120
13-18	30	300	20	380
19-24	100	500	30	410

Operational requirements for the company's existing applications total 400 computer system hours and 200 analyst-programmer hours. These requirements increase by 10% at the end of each six-month period.

The firm presently employs six analyst-programmers who work eight hours per day for an average of 22 days each month. Of the total of 720 hours of available computer time per month (30 days x 24 hours per day), 80% is used for productive work.

Required:

a) At what point in time will a significant increase in the capacity of Perry's computer system become necessary?
b) Assume that a new computer system is to be acquired and that the conversion to this new system will be complete as of the first day of month 13. Further assume that one analyst-programmer will devote full-time effort to implementing this conversion during the six months preceding the first day of month 13. How many full-time analyst-programmers must Perry employ during each of the four six-month periods?
c) Assume that: (1) the monthly salary of an analyst-programmer is $1,000; (2) the monthly hardware rental and all other fixed costs for the present system total $8,000, and will total $12,000 for the new system when implemented; (3) upon implementation, the new system will exactly triple throughput; and (4) all variable costs relating to the operation of both the old and new systems, during both productive and nonproduc-

tive time, total $10 per hour. Prepare a financial projection of the monthly total of all of these costs for each month over the four-year period.

43. Prepare a microflowchart of a program incorporating several control features as described below.

    A file is read which contains an employee identification number, a department number, employee name, pay rate, hours worked, gross pay, net pay, and total deductions. The program performs various control checks and edits as follows:

    a) Sequence check – the cards are checked to assure that they are in numerical sequence by employee identification number.
    b) Field check – the department number is checked to assure that it contains numeric data.
    c) Validity check – the employee identification number is checked to assure that it is either less than 2,500 or greater than 4,300.
    d) Limit checks – pay rate and hours worked are checked to assure that they do not exceed $18.00 and 70, respectively.
    e) Sign check – net pay is checked to assure that it is positive.
    f) Edit check – gross pay for each record is tested to assure that it is equal to the product of pay rate and hours worked.
    g) Crossfooting balance test – at the completion of processing, the total of gross pay is compared to the sum of the total of net pay and of deductions.
    h) Control totals – a hash total of employee identification number, a record count, and financial totals of gross pay and total deductions are accumulated during processing and checked for accuracy against predetermined control totals read from the trailer label.

    If an error is encountered by checks (a) through (f), the record data is printed out together with an error message. Each record should be checked for the existence of all of these conditions, so some records may be printed out more than once with more than one error message. When processing is completed, messages should be printed out indicating whether or not conditions (g) and (h) are satisfied.

44. You have been engaged by Central Savings and Loan Association to examine its financial statements for the year ended December 31, 1967. The CPA who examined the financial statements at December 31, 1966 rendered an unqualified opinion.

    In January 1967 the Association installed an on-line real-time computer system. Each teller in the Association's main office and seven branch offices has an on-line input output terminal. Customers' mortgage payments and savings account deposits and withdrawals are recorded in the accounts by the computer from data input by the teller at the time of the transaction. The teller keys the proper account by account number and

enters the information in the terminal keyboard to record the transaction. The accounting department at the main office has both punched card and typewriter input-output devices. The computer is housed at the main office.

Required:

You would expect the Association to have certain internal controls because an on-line real-time computer system is employed. List the internal controls which should be in effect solely because this type of system is employed, classifying them as:

a) Those controls pertaining to input of information.
b) All other types of computer controls.[1]

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[1]Adopted from Question 2, Auditing Section, American Institute of Certified Public Accountants Examination, May 1968. Copyright © 1968 by the American Institute of Certified Public Accountants and reprinted with permission

PART FOUR

ACCOUNTING INFORMATION SYSTEMS APPLICATIONS

Chapter 12

Accounting Information Systems for Marketing Management

All business organizations must produce a product or provide a service for which a market demand exists. From this market demand must be generated a stream of revenue sufficient to cover the firm's costs and expenses, replace its assets, and provide its capital suppliers with a return on their investment. The accounting information system plays an important role in this revenue generation process since it is a primary source of information to the executives who manage the marketing function. The accounting system is also responsible for processing all customer transactions.

It is therefore evident that a close relationship must exist between the accounting and marketing functions in a business organization. This chapter explores the general nature of that relationship. The decision responsibilities and information requirements of the marketing function are described, and the role of the accounting information system in meeting these information requirements and in processing sales transactions is explained and illustrated. The discussion is intended to be general in nature rather than descriptive of the real system of a specific company.

The remaining chapters in Part Four examine the relationship of the accounting information system to other functional areas of management within a typical business organization. Chapters 13 and 14 cover the logistics function, while Chapters 15 and 16 cover the personnel and finance functions, respectively. The purpose of these chapters is to integrate and illustrate the application of the concepts, tools, and technology covered in the first three sections. In particular, the concepts of control and organization, the tool of flowcharting, and the technology of computer based information systems are stressed.

In Part Four, the various subsystems of the accounting information system are discussed separately rather than as one total system. This is done primarily as a matter of convenience of presentation, however, and should not obscure the fact that the various functional areas are very much interdependent in terms of both operations and information. As the reader proceeds through Part Four, the interrelationships among the various information subsystems should be noted.

THE MARKETING MANAGEMENT FUNCTION

In Chapter 2 it is emphasized that knowledge of the organization structure of a company provides the systems analyst with important insights into the decision responsibilities and information requirements of the various managers and personnel within the organization. This and subsequent chapters apply this concept by illustrating typical forms of organization within each of the several functional areas of business firms. The illustrations provide a framework for discussion of decision responsibilities and information requirements within each functional area. Figure 12.1 provides an example of a typical marketing organization structure. Each of the executive positions shown in the chart is examined in this section.

The Top Marketing Executive

The Vice President of Marketing is responsible to the company President for the effective planning, coordination, and control of the marketing effort. He participates in company-wide planning, specifically as it relates to marketing activities. He must participate with other top level executives in the establishment of pricing policies which encompasses not only setting base prices, but also instituting discount policies, credit terms, and warranty policies. He also may participate in the most significant policy decisions relating to the specific areas for which his staff executives are responsible, such as new product introduction or the planning of a major advertising campaign. He must review and evaluate the performance of the executives under him.

The Marketing Vice President in a business organization may be looked upon as a strategist seeking an optimal allocation of his scarce resources to achieve the maximum advantage for his firm in the environment of the marketplace. His scarce resources include manpower – that of his staff specialists and sales force – and funds. He must allocate these resources among such activities as selling effort, advertising and promotional campaigns, marketing research studies, and so forth. Environmental forces include customers, competitors, the economy, and government.

To fulfill his responsibilities, the Vice President of Marketing relies on the extensive information he obtains from various sources. The planning function requires environmental information on such matters as economic trends, competitors' plans, and customers' attitudes, as well as internally generated information such as sales forecasts and market research studies. The pricing decision requires all of the above kinds of information plus internal information on the cost of products and the cost of credit and warranty policies. The control function requires information as a basis for evaluating the performance of all subordinate executives.

Director of Sales

The Director of Sales is responsible for the effectiveness of the selling effort within the firm. He participates in the planning of sales with the Marketing

administer a staff which responds to customer complaints or which reviews the adequacy of retail facilities, or he may administer a maintenance organization if the product is a technical one. The basic objective is to assure that the customer achieves the level of satisfaction of needs or desires which he expects from the product.

The information used in the Customer Service function is for the most part obtained directly from customers and includes requests for information or technical assistance, complaints, requests for maintenance, and so forth. Information on the incremental cost of customer service activities and the performance of customer service personnel is useful for purposes of control.

Director of Marketing Research

The Director of Marketing Research is responsible for planning and administering the data gathering and analysis activities of the Marketing Research Staff. This staff carries out special studies of consumer behavior and other subjects of interest to marketing executives. The Director must allocate scarce resources among alternative projects and interpret the results of such projects for other marketing executives and top management. Marketing Research studies are often a primary basis for planning in such areas as new product introduction, advertising, and pricing. For the most part the Marketing Research Staff is not a user, but a producer, of information, which it generates from data collected by means of scanning the environment.

SOURCES OF MARKETING INFORMATION

In terms of volume of information, the accounting information system is the primary source of marketing information in most business organizations. However, a well-managed marketing activity cannot rely solely on financial information, and must therefore exploit other sources of information, including its own salesmen and staff personnel, other departments within the firm, and the environment. This section discusses the nature of the data collected and the information generated from each of these sources.

The Accounting Information System

The accounting information system is a source of two basic types of information to marketing management: information generated from the processing of 1. sales orders, and cost reports and analyses. 2.

Sales order processing. The sales order processing cycle begins with the initiation of an order by a customer and ends with the delivery of goods to the customer. The basic data source is the sales invoice, an example of which is illustrated in Fig. 12.2. The invoice serves as a record of the sales transaction, and copies sent to the customer provide notice that shipment has been made and payment is due. Note how much of the data collected on the sales invoice

NEEDMORE MANUFACTURING COMPANY

987 Glendale Needmore, Tx 78799 Tel 512/836 0107 Invoice No 10001

INVOICE

Customer Order No	Order date	Salesman Code	Customer Account No
45236	7/10/72	24 – 76	24 – 93106

Sold to	Ship to
Hardware Wholesalers 1006 East 61st Austin, Texas 78744	Same

Shipper	Date shipped	Invoice date	Terms of sale
Austin Trkg 24061	7/12/72	7/12/72	2/10, net 30

Item code	Description	Quantity ordered	Back ordered	Quantity shipped	Unit price	Item total
10562	Hammer	100		100	$1 00	$100 00
20651	Sickle	50	20	30	1 75	52 50
38214	Hoe	50		50	2 50	125 00
38526	Rake	80	30	50	3 25	162 50
	Freight					5.61
	Total					$445 61

Fig. 12.2 Sales Invoice

is coded to facilitate subsequent processing. For example, the salesman number, customer account number, and item code provide a basis for generating sales and profitability analyses by salesman, by customer, and by product. In addition, the invoice itself is numbered to provide a basis for future reference and audit.

Data from the sales invoice is used in maintaining three major files which contain information useful to the marketing department. These files are a finished goods inventory file, an accounts receivable file, and a sales summary file. The finished goods inventory file is used to check on inventory availability at the time of the sale. The accounts receivable file and credit history are used as a basis for evaluating the credit worthiness of a customer who has placed an order. The sales summary file is used to generate the various sales analysis reports which provide vital management information to marketing executives.

Sales analysis reports generally present dollar and/or unit sales for the most recent period (week or month) and for the year to date. In addition, for comparison purposes it is useful if sales quotas and/or prior year sales are reported along with actual sales for the current period. An example of a report analyzing sales by territory, and by salesman within territory, is provided in Fig. 12.3. A report of this type would be useful to the sales manager of a territory for purposes of evaluating his sales force. Similarly, a report analyzing sales by territory within a region would be useful to a regional sales manager in

Period ending March 31, 1972		Territory East Texas				
Salesman	Period	Actual sales	Prior year	% Change	Quota	% Variance from quota
Benjamin, H L	This month	$5,000	$ 4,000	+ 25%	$ 4,800	+ 4%
	Year to date	12,000	11,500	+ 4%	12,500	− 4%
Carlton, J C	This month	$4,000	$3,800	+ 5%	$ 4,500	− 11%
	Year to date	10,500	11,000	− 5%	13,000	− 19%
Territory totals	This month	$30,000	$28,550	+ 5%	$35,000	− 14%
	Year to date	85,000	84,000	+ 1%	95,000	− 11%

Fig. 12.3 Sales analysis by salesman and territory.

evaluating territorial sales managers, whereas a report of aggregate sales by region would be useful to the Director of Sales in evaluating regional sales managers.

Within a typical business organization, sales may be analyzed according to several detailed and aggregate classifications to provide useful information to various marketing executives at all levels of the organization. In addition to breakdowns by salesman, territory, and region, sales may be analyzed by individual product, product class, major customers, type of customer, distribution channel, and so forth. Furthermore, reports may be prepared in which sales are detailed according to two or more classification categories. Examples would include a breakdown of sales by product for key customers, or by type of customer for each territory. Sales analyses are useful not only because they provide a historical summary for control purposes, but also because they provide information relevant to planning advertising and promotional campaigns, selling activities, price changes, composition of product lines, and other marketing activities.

Profitability analysis reports are generated from sales records together with product cost data. Such reports generally may be prepared using the same categories of classification as sales analyses. An example of a profitability analysis by product class and model for a customer is illustrated in Fig. 12.4. This sample report reveals that the contribution margin (excess of revenues over variable costs) for this customer exceeds the amount budgeted, primarily because unfavorable volume variances for low margin products in each class are more than offset by favorable volume variances among high margin products. This type of information is useful to salesmen and sales managers for purposes of allocating sales effort among products and customers. Similar product profitability breakdowns may be generated by distribution channel, by territory, or

ATLANTA WHOLESALE APPLIANCE COMPANY

Account number 16520

Date October 31, 1973

Product		Per unit gross margin	Year-to-date Totals					
				Unit sales				
Class	Model		1972 actual	1973 actual	1973 budget	Actual contribution margin	Budgeted contribution margin	Variance
Refrigerator-Freezer	RF-10	$ 40	1,800	2,000	2,100	$ 80,000	$ 84,000	$ (4,000)
	RF 14	60	3,500	4,000	4,100	240,000	246,000	(6,000)
	RF 16	80	3,000	3,600	3,500	288,000	280,000	8,000
	RF-20	100	1,200	1,500	1,400	150,000	140,000	10,000
Freezer	F 16	75	1,100	1,280	1,300	96,000	97,500	(1,500)
	F 20	90	1,500	1,750	1,800	157,500	162,000	(4,500)
	F-24	130	600	750	700	97,500	91,000	6,500
Totals, all products						$1,109,000	$1,100,500	$ 8,500

Fig. 12.4 Profitability analysis by product for key customer.

by salesman. Aggregate product profitability information may also be generated for use by top level marketing executives in product planning.

A third major category of information generated from the processing of sales orders includes various analyses of sales trends. For example, projections developed from sales trends are useful for purposes of forecasting sales; sales forecasts, in turn, can be utilized in the planning and control of marketing activities. Further, analyses of historical sales trends contribute to evaluating the success of various marketing actions, such as advertising campaigns, special promotions, or price changes.

The procedures involved in processing sales order transactions, maintaining the related files, and generating the various reports are described in detail in a later section of this chapter.

Cost reports and analyses. All cash disbursements made by an organization must be recorded by its accounting system. A good system will record enough information about the nature and purpose of each disbursement to enable useful reports to be generated. One significant example is information about product costs. This information is used in establishing pricing policies, in product planning, and in various profitability analyses. Manufacturing companies generally maintain fairly elaborate cost accounting systems to generate accurate and useful product cost data.

To be most useful, product cost information should be segregated according to the fixed and variable components of manufacturing costs and selling expenses. For purposes of marketing cost control, each detailed element of selling expense should also be segregated into its fixed and variable elements. Ordering

information in this way enables marketing management to evaluate the incremental cost of various alternative marketing actions under consideration.

Though incremental product cost information is very useful to marketing management, it is also very difficult for an accounting system to provide. The primary problem is that not all cost elements are either rigidly fixed or directly variable with unit sales volume. In addition, the accounting systems of many firms are designed to fulfill external reporting requirements, which dictate that the cost per unit of a manufactured product must include all manufacturing costs, including both fixed and variable costs. Selling expenses are generally reported as one lump sum or according to functional classifications, with no recognition given to their fixed and variable components. Most data classification systems, such as charts of accounts, were originally designed primarily to facilitate external reporting. In order for accounting information systems to provide incremental cost information, each type of cost must first be separated into fixed and variable components, and then systems of data collection and classification must be redesigned to facilitate the necessary processing steps.

In addition to product cost information, a firm's accounting information system should provide cost reports by responsibility centers within the marketing department. These reports compare costs incurred to budgeted costs for each responsibility center. Such reports are useful to marketing executives for controlling the allocation of budgeted funds to their most profitable uses. In addition, project cost reports comparing and analyzing estimated and actual costs for significant marketing projects should be prepared. Examples of such projects would include market research studies, advertising campaigns, and other promotions and surveys.

The accounting information system must also participate in the preparation of revenue and cost projections upon which decisions regarding new product introduction are based. While records of sales of similar products provide one basis for revenue projections, per unit cost projections are developed using the estimates of labor and material requirements obtained from the engineering department. An estimate of the amount of the initial cash outlay for promotion and new equipment is also required. Once all cash flow projections have been made, the decision should be based upon a capital budgeting analysis which predicts the expected present value and risk factors involved in the decision. Accounting executives are generally familiar with capital budgeting techniques and should participate in the development of these analyses.

Several subsystems of the accounting information system contribute to the generation of cost information and reports of the type discussed in this section. The next four chapters discuss further the structure and operations of these subsystems.

The Marketing Department

A significant share of the information which the marketing department uses for marketing management is typically generated from within the department. One

SALESMAN ACTIVITY REPORT

Salesman		Date of call	Time spent
Name	Number		

Account data

Name ____________ Acct number ____________

Address ____________ Buyer's name ____________

____

Type of store		Account status		Order status	
	Furniture sales		Prospect		Order received
	Local dept store		Old account		Will send later
	Dept store chain		New account		Won't buy now
	Other		No interest		No interest

Comments

Fig. 12.5 Salesman's call report.

significant data source in this category is the salesman's call report, an example of which is illustrated in Fig. 12.5. This report is intended to be filled out by each salesman for each call he makes on a customer, whether or not the customer makes a purchase. All firms would not necessarily find it appropriate to collect and utilize data of this sort, but where the technique is employed, it yields a very useful source of information for evaluation of the sales force and of feedback from customers regarding their needs of, and opinions on, the firm's products.

The marketing research studies prepared by the Marketing Research Department constitute a second significant source of marketing information within the marketing department. These studies may range from pilot studies of consumer reaction to the introduction of a new product or to a new advertising campaign in a limited market area, to general surveys of customer attitudes throughout the country. Such studies may be performed as needed by other marketing departments or on a regular basis. The primary source of data input for these studies is the external environment. The Marketing Research Staff applies its expertise in statistical sampling and statistical inference techniques to "process" these data into information. Marketing research information is potentially useful to almost all marketing decisions which involve the planning function.

A third important source of marketing information within the marketing department consists of sales forecasts. Estimates provided by the sales force play a major role in developing such forecasts, although historical records of past sales are also important. Sales forecasts are used as a basis for planning the activities of the entire firm, and are also very useful as standards for management control of the sales force. Statistical techniques such as exponential smoothing or regression and correlation analysis may be used to generate these forecasts.

Other Internal Sources

In addition to the accounting and marketing departments, other departments within a firm may contribute significantly to the flow of information to marketing personnel. For example, the production and/or engineering department may provide information relating to product quality or design which is useful to product planning or to salesmen. The economics department, if one exists, may provide useful analyses of the economy or of the particular industrial field within which the firm operates. The personnel department may provide information relating to potential marketing department employees. In many firms, a smooth interface between the marketing department and a research and development department is essential to product planning. While information from all of these sources may be important, it is generally not as regular or as voluminous as the information provided by the accounting department or that generated within the marketing department itself.

External Information Sources

Much useful marketing information may be obtained directly from scanning the external environment without the need for an intermediate data processing step. One type of information which fits within this category relates to the activities and plans of competitive firms. Information about the nature of the products, prices, and advertising of competitors is very useful to marketing planning. Information about the plans of competitors is not easy to obtain but is also extremely useful. Trade publications, the promotional literature of competitors, and communication with customers are potential sources of this information.

General information on economic and industry trends may also be obtained directly from the environment. Information on demographic characteristics of the market — rural vs. urban; population, education, and income levels; population in various age groups; etc. — falls in this category. The United States Bureau of the Census and other federal and state government agencies comprise one important source of such information. Trade associations which gather, analyze, and distribute information relating to a particular industry are another.

There are definite problems with respect to deciding what environmental information is needed and establishing a regular mechanism for its acquisition and analysis. Unlike accounting information, environmental information is not

made available automatically as the by-product of some other essential business process. Marketing executives must accept the responsibility for becoming familiar with external information sources and obtaining the environmental information which is of most relevance to their particular functions.

THE SALES ORDER PROCESSING SYSTEM

The general nature of the input to and output from the sales order processing system has already been discussed. This section will outline the accounting transactions involved in the process, fully examine the nature of the master files maintained, and then describe in detail an example of: (1) a manual system, (2) a computer based batch processing system, and (3) a real-time system for processing sales orders and generating marketing information.

The Accounting Transactions

The primary accounting journal entry reflecting sales order processing appears as follows:

Accounts Receivable	XXX	
Sales		XXX

Almost all sales of a manufacturing company, as well as a significant portion of the sales of retail companies, are recorded in this manner. For firms which maintain inventory on a perpetual basis, these sales entries are accompanied by the following entry:

Cost of Goods Sold	XXX	
Finished Goods Inventory		XXX

Certain variations from these basic entries may also occur. For example, when a customer returns merchandise, or asks for an adjustment in price because of damaged merchandise, the following entry is made:

Sales Returns and Allowances	XXX	
Accounts Receivable		XXX

These journal entries represent the most important transactions which are initiated as a result of sales order processing. Transactions involving the collection of accounts receivable are treated in Chapter 16.

In manual systems, journal entries are usually recorded either in a general journal or on a journal voucher. The manual systems described in Chapters 12 through 16 assume that journal vouchers (see Fig. 12.6) are used. In this way, illustrative document flowcharts of these systems (such as Fig. 12.10) show the exact point in the system at which journal vouchers are prepared for each of the important journal entries initiated by the process.

JOURNAL VOUCHER

Date 7/6/73

Voucher Number 3706

Prepared by	Approved by	Posted by
J Mitchell	J Hoover	N Richards

Account Number	Account Title	Amount Credit		Amount Debit	
5 112	Accounts Receivable Control	$42,635	91		
5 113	Sales			$42,635	91

EXPLANATION
To record total daily billings

Fig. 12.6 Journal voucher.

The Master Files

The three primary master files maintained as part of the sales order processing system have already been identified. These are: an accounts receivable master, a finished goods inventory master, and a sales summary master.

An example of the data content and organization of a record in an accounts receivable master file appears in Fig. 12.7. Each accounts receivable record contains a single value for all of the data fields listed except those which are indented in the illustration. Values for the data fields which are indented may appear from zero to several times in a record, depending upon the number of transactions the particular customer has had since his last monthly statement. If the file records are recorded on a document or ledger card, there will be a separate line for each transaction. If the file records are recorded on a machine readable medium, such as magnetic tape or disk, each record will indicate the exact number of transactions it contains, and the number of characters or bytes of data in each record will vary depending upon the number of transactions. In the terminology of file organization, a set of fields such as this which may be replicated a number of times within a record is called a *subrecord.* As will become evident, subrecords are a common element in business files.

Basic inputs to the accounts receivable master file include routine sales and cash receipt transactions. Other types of input transactions include the addition of new records to the file, credits for sales returns and allowances, ac-

Customer account number (control field)
Customer name and address
Credit rating
Credit limit
Balance due as of last monthly statement
Transactions since last monthly statement:
  Transaction type code
  Document number
  Date
  Amount
Current balance

Fig. 12.7 Content and organization of an accounts receivable record.

count writeoffs, changes of address, and other nonroutine adjustments and corrections. Basic outputs of the file include periodic statements of account which are sent to customers, responses to requests for credit approval for individual customers, and various reports such as the accounts receivable aging schedule.

A list of some of the basic data elements of a record in the finished goods inventory file of a manufacturing company is shown in Fig. 12.8. In addition to these data items, a finished goods record might also contain subrecords for recent sales, completed production orders, and other transactions, as well as subrecords for open customer orders requesting a future delivery date. Further, the record might contain a summary or average of recent sales activity and a forecast or quota for future sales. It is also likely that each record of an inventory item which is temporarily out of stock will contain a subrecord for all *backorders.* These are customer orders which are not filled upon receipt due to insufficient supply, but which are maintained on file to be filled when the stock is replenished.

Basic inputs to the finished goods inventory file include records of sales transactions, production orders initiated, and production orders completed, as well as miscellaneous additions, corrections, and adjustments. The file provides important reference information for production planning, warehouse and stockroom operations, and selling operations. The file may be used to generate such output reports as: a *stock status report,* which is a listing of all data items for each record in the file; a report of items out of stock or below the prescribed minimum stock level; or an analysis of product turnover.

The nature, content, and organization of the sales summary file varies greatly depending upon the characteristics of the system. In an automated system, a record in this file might be constructed as shown in Fig. 12.9. Each such record summarizes the total sales of a particular product by a particular salesman in a particular territory to a particular customer. Each sales total on a record is stated in terms of units and dollars and in terms of the most recent period and the year to date. Comparable prior year figures and quotas are also in-

Stock number (control field)
Item description
Location code
Standard cost per unit
List price
Minimum stock level
Production lot size
Quantity on hand
Quantity in process
Estimated completion date

Fig. 12.8 Basic data elements of a finished goods inventory record.

Customer number
Inventory stock number
Territory number
Salesman number
Total sales this week - units - actual
Total sales this week - units - prior year
Total sales this week - units - quota
Total sales this week - dollars - actual
Total sales this week - dollars - prior year
Total sales this week - dollars - quota
Total sales year to date - units - actual
Total sales year to date - units - prior year
Total sales year to date - units - quota
Total sales year to date - dollars - actual
Total sales year to date - dollars - prior year
Total sales year to date - dollars - quota

Fig. 12.9 Data content and organization of sales summary record.

cluded in each record. This form of organization enables the sales summary file to be used for generating sales analyses by customer, by type of customer (if a subcode for type of customer is included in each customer's account number), by product, by product class (if a subcode for product class is included in each inventory stock number), by territory, by salesman, or by any number of cross-classifications of the above categories. Each sales analysis report could show any or all of the sales data indicated, as well as percentage changes of current sales from the prior year and percentage variances of actual sales from quota as computed by the report generating program.

In a manual system, the cost of maintaining sales summary records and preparing sales analysis reports often precludes their use. Alternatively, limited sales summary records may be maintained by recording all sales in columnar

sales journals, in which a separate column is used to record sales of each product. A second columnar journal in which each column represents a salesman might also be used. Columnar totals from these journals would provide sales analyses by salesman and product. Bookkeeping machines might be used to facilitate the recording and summarization steps in this process.

A Manual System

The document flowchart in Fig. 12.10 illustrates one example of a manual system for processing sales orders in a manufacturing company. Most such companies will differ in some ways from this example, but the general pattern of information flow will not vary a great deal from the illustration in most cases.

The illustration shows the sales order process beginning with the receipt of the customer's purchase order, which is used to prepare a sales order. Actually the sales order may have been prepared previous to the receipt of the purchase order by a salesman in the field or by a sales order clerk receiving telephone orders. Once they have received an order, most industrial firms will transmit some form of documentary acknowledgment to the customer. As shown in the illustration, this is commonly a duplicate copy of the customer's purchase order.

The sales order contains basically the same data as the invoice except for such things as item *extensions* (price times quantity calculations), shipping charges, taxes, invoice total, and credit terms. In cases where the quantity delivered is less than the quantity ordered, the extra units are backordered. A notation is made in the finished goods file so that when the stock is replenished the goods will be automatically shipped to the customer. Many firms, particularly those in which backordering is not common, do not use a separate sales order document. Instead, they begin to prepare the sales invoice immediately upon receipt of orders, and use extra copies of the invoice in place of the several copies of the sales order.

One copy of the sales order is filed numerically in the sales order department. Three other copies are sent to the finished goods storeroom or warehouse. If the customer's credit is not established, the sales order may be routed through the credit department, where a credit check is performed before shipment is authorized. In the finished goods storeroom the products ordered are retrieved from available stock. The sales order serves as an authorization to release the goods to the shipping department, and is used as a source document to post shipments to the finished goods inventory file. If any goods ordered are backordered, a notation to that effect is made on the sales order, and one copy is filed by storeroom personnel for future reference.

Those goods which are in stock are assembled and transferred to the shipping department, along with two copies of the sales order. To acknowledge the transfer of responsibility for these goods from the storeroom to shipping, an employee of shipping will sign a copy of the sales order indicating the exact quantities to be shipped. This copy will then be sent to billing. The remaining copy of the sales order may be enclosed as a *packing slip* with the goods as they are shipped to the customer.

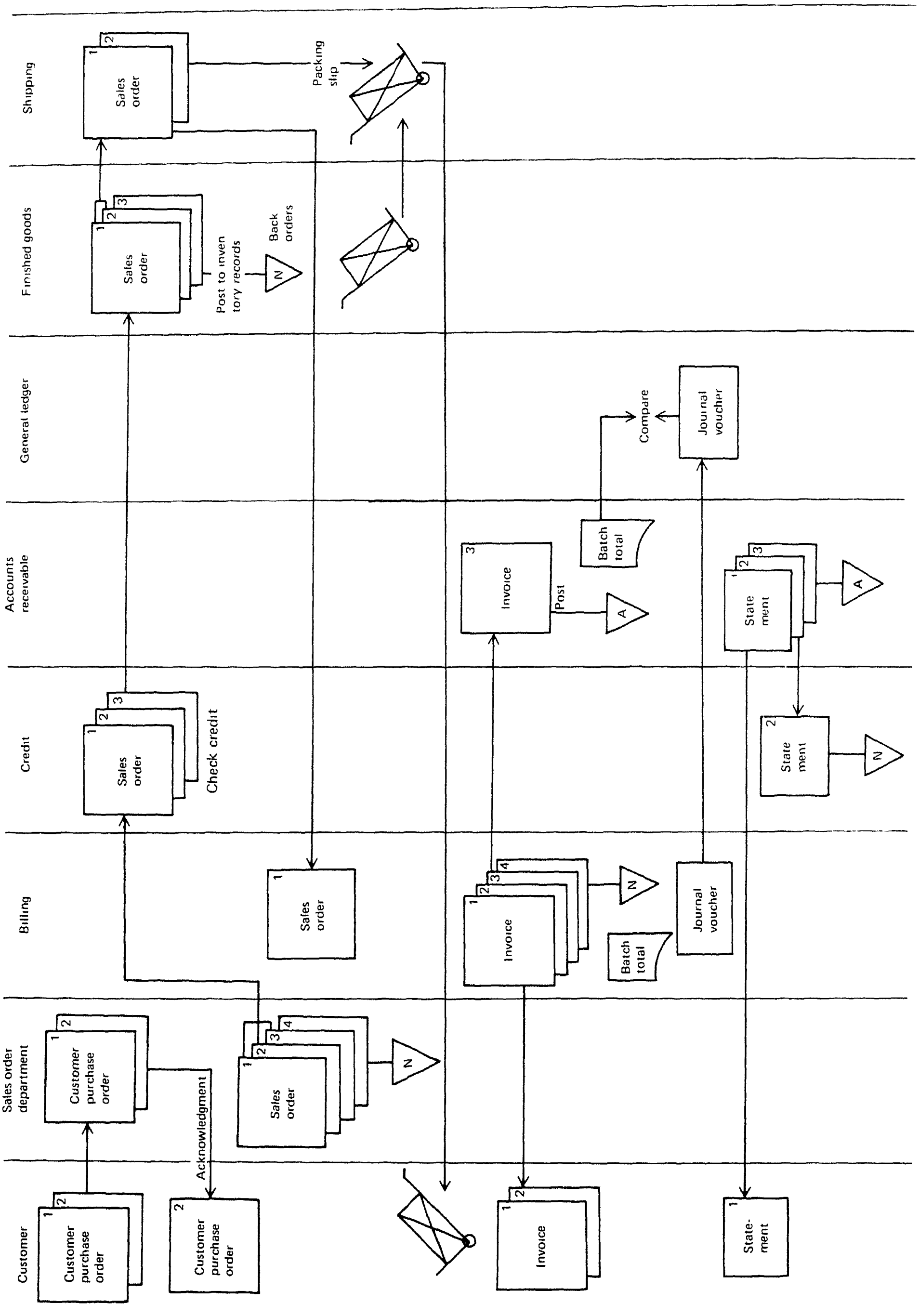


Fig. 12.10 Document flow in a manual system for sales order processing.

In the billing department the sales order evidencing the transfer of goods to shipping provides the basis for preparation of the invoice. After the invoice is prepared, the first (and often a second) copy is sent to the customer. Another copy is sent to the accounts receivable department where it is used to post the billing to the customer's account and is then filed alphabetically by customer name. One other copy of the invoice is filed by invoice number in the billing department.

An example of the use of batch totals for control purposes is found in this process. The billing department compiles a batch total of the amount billed on all invoices in a batch. Once preparation of the batch is complete, the billing department uses the batch total to prepare a journal voucher. The journal voucher contains the summary entry debiting accounts receivable and crediting sales for the total amount billed, and is sent to the general ledger clerk. In the accounts receivable department, as invoices are posted to the subsidiary ledger, another batch total is prepared. This second batch total is compiled by summing the individual ledger balances after posting and subtracting the sum of the individual ledger balances prior to posting. This total is also sent to the general ledger section where it is compared to the amount of entry on the journal voucher. Any discrepancy between these two totals indicates the existence of one or more errors, which can then be discovered and corrected.

Periodically, usually at the end of each month, the accounts receivable department may prepare a statement of each customer's account, detailing transactions in the most recent period and indicating the total amount due on account from the customer. One copy of this statement is sent to the customer, another is kept by accounts receivable, and another may be sent to the credit department for their records. Statements of this sort are commonly prepared and utilized by retail businesses, but are generally not used in regular dealings between industrial firms.

Organizational independence with respect to the sales order process is achieved by separation of the custodial functions performed by finished goods and shipping from the recording functions performed by sales, billing, and accounts receivable. This separation of duties helps to assure that only goods intended for shipment to customers are removed from the finished goods storeroom, and that all such goods are properly billed.

Special procedures must be established for handling sales returns and allowances. Each adjustment should be approved by a person in a position of responsibility, such as the Credit Manager. The basis for approval should be a letter from the customer. Issuance of a credit memo formally recognizing the adjustment should, in the case of sales returns, also require a receiving report as verification of the return of goods. A copy of the credit memo is sent to the customer, another is filed, and another is used as a source document for posting to the accounts receivable ledger. At the end of a day or week, the person authorizing these credits should prepare and send to the general ledger

clerk a journal voucher containing a summary entry for all sales returns and allowances during the period.

In a manual system, the periodic generation of reports such as sales analyses may not be feasible. In very small companies, no such reports need be generated because the manager or owner probably knows enough about his customers and sales. Somewhat larger companies would probably use a bookkeeping machine to prepare invoices. Some summary totals can be accumulated by such machines, and so limited sales summaries could be generated. The bookkeeping machine also speeds processing of invoices by generating extensions and invoice totals automatically and combining the steps of invoice preparation and posting to the accounts receivable file.

A Computer Based Batch Processing System

A document flowchart of the sales order and accounts receivable process for a typical manufacturing company using a computer based system appears in Fig. 12.11. It is assumed that the system uses punched card input and maintains master files on magnetic tape. Once again, it must be emphasized that the illustration is not intended to demonstrate how the process should be accomplished, but to show one example of how it might be done.

A comparison of Fig. 12.11 with its manual counterpart, Fig. 12.10, reveals that procedures relating to sales order preparation, credit checking, order assembly in finished goods, and shipping are the same. However, the functions of billing and accounts receivable have been replaced by data processing. When the shipping department is finished with a sales order, it sends a copy indicating which items were shipped and which were backordered to the input preparation (keypunching) department. This department punches and verifies cards for each individual item shipped or backordered. These cards become input to a series of computer runs which: produce invoices, update the accounts receivable master file, update the finished goods inventory master file, produce a list of inventory items which are out of stock or in short supply, update the master sales file, produce a sales analysis report at the end of each week or month, produce customer statements of account at the end of each month, and produce an aged accounts receivable schedule at the end of each month. A systems flowchart of the computer operations necessary to accomplish these various processes appears in Fig. 12.12.

To simplify its interpretation, the systems flowchart is separated by dashed lines into four separate categories of operations. These are: (1) input preparation and data control, (2) accounts receivable and billing, (3) inventory, and (4) sales analysis. Each of these four sets of operations is discussed in turn in this section. Also discussed are a number of control policies and procedures relating to these processes. The section concludes with a discussion of the use of disk units rather than magnetic tape as a file storage medium in the system.

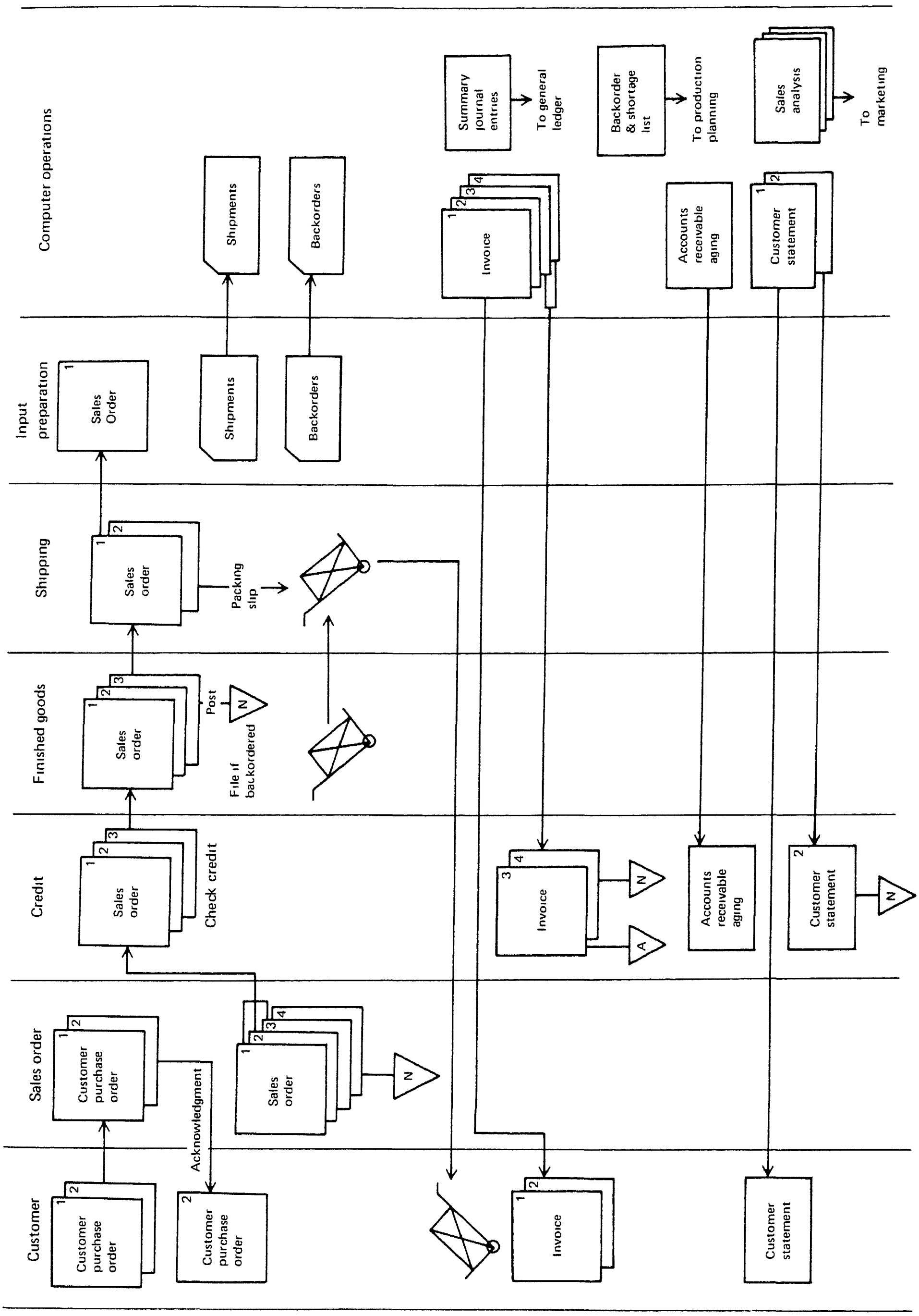


Fig. 12.11 Document flow in computerized batch processing of sales orders.

Input preparation and data control. Each day this operation begins with the assembly of sales orders in batches and the preparation of batch totals. For each batch of sales orders, control totals which could be accumulated include record counts of the total number of sales orders, shipments, and backorders as well as hash totals of customer account numbers, inventory stock numbers, or the number of units ordered. The batch totals are retained and compared to summary totals generated by subsequent computer processing to help assure that no records are lost during processing or improperly processed. The next step in input preparation is the keypunching and verification of a shipment or backorder card for each item ordered. These cards are then sorted on a card sorter into sequential order by customer account number for processing against the accounts receivable master file.

There are several alternative methods by which these input preparation operations could have been accomplished. For example, the shipment and backorder cards could have been converted to magnetic tape prior to the accounts receivable processing, using either a converter or a card-to-tape routine on the central processor. Alternatively, the records could have been keyed directly onto tape using a key-to-tape encoder if one were available. In either case, the records on tape would then be sorted by the central processor utilizing a tape sort routine. Once sorted, the records are ready for processing to update the accounts receivable file and prepare invoices.

Accounts receivable and billing. The main step in this operation is the daily processing of shipment and backorder records to update the accounts receivable master file for sales on account. This process is done by the accounts receivable department in the manual system. Both of the inputs to this run, the transaction records and the old accounts receivable master, are sequenced by customer account number. The updating process results in the addition of the amount billed to each customer to that customer's record on the master file. In addition to generating an updated accounts receivable master tape, this run produces multiple copies of a customer invoice for each customer order. In the manual system, the invoice preparation function is performed by the billing department.

A third output of this run is a listing of error transactions and summary information. Error transactions include any input records which failed an input validation routine or other processing check in the program. This list should be provided to the data control clerk for follow-up and error correction. The summary information includes both the batch totals accumulated during the run and the summary journal entry debiting accounts receivable and credit-sales. The batch totals are checked against those prepared prior to keypunching. The process of posting the summary journal entry to the general ledger may either be done manually or by a separate computer process.

The fourth output of this processing run is a tape listing of the shipment and backorder cards. This tape is generated because the data is used as input to several other processing runs. The use of tape as the input media for those runs

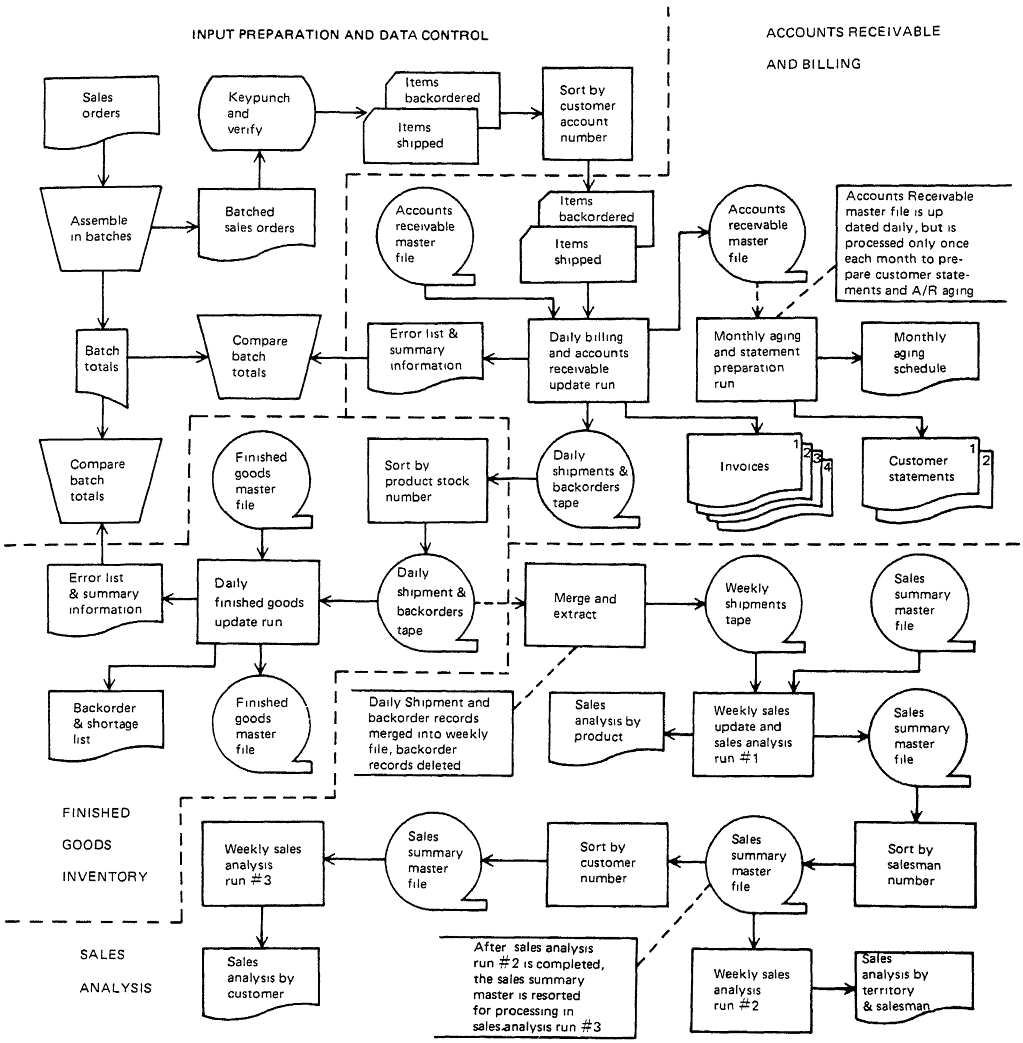


Fig. 12.12 Systems flow in computerized batch processing of sales orders.

speeds up processing in two ways. First the speed with which data can be read from tape is many times faster than the speed of card reading. Second, each separate run requires that the data be sorted on a different control field, and tape sorting is much faster than card sorting. Therefore the preparation of a tape of these records in this run is much more efficient than continued use of the card records as input.

The second main process illustrated in the accounts receivable section of the flowchart is a monthly run utilizing the accounts receivable master file as input. This run results in the preparation of statements of account, which are mailed to customers, and an aging schedule of accounts receivable, in which each customer's account is categorized according to whether and by how much it is past due. The aging schedule is submitted to the credit department for use in customer credit checks, and to initiate special collection procedures where necessary.

Inventory processing. This portion of the flowchart illustrates those operations necessary to update the finished goods inventory master file for shipments and backorders. The first essential step is that the shipment and backorder records be sorted into sequential order by the inventory stock number, which serves as the control field of the finished goods master. The next step is the updating run itself, in which shipment records are posted as reductions to the on-hand balance of the respective item, and backorders are recorded on the appropriate records in the file. In addition to generating an updated version of the finished goods master tape, this run prepares a report of backordered items and other items for which the on-hand balance is below the minimum stock level, and a report of error transactions and summary information. The backorder and shortage report may be provided to the production planning department to aid in decisions regarding which items should be produced. The batch totals from the summary information are compared to those obtained prior to keypunching. Also included in this summary information is the summary journal entry debiting cost of goods sold and crediting finished goods inventory for the inventory shipments.

Sales analysis. The illustration assumes that sales analysis operations are performed weekly, although a monthly cycle is also quite common for this process. The sales summary file is used to generate sales analysis reports, but this file must first be updated for sale transactions of the most recent week. The shipment records from the shipments and backorders tape are used for this purpose. The several daily shipments and backorders tapes must be merged into a single weekly shipments tape, with the backorder records extracted from the tape during this step. Since the individual shipment and backorder records were already in sequence by inventory stock number, the merged weekly shipments tape is also sequenced in that order.

The next step is the processing of the weekly shipments tape to update the sales summary master file. Since this process is performed sequentially, the sales summary master must also be in sequence by inventory stock number. As a by-product of this updating process, a sales analysis by product item and product class may be generated.

Before other sales analysis reports may be prepared from the sales summary master file, the file must first be sorted according to the control field for which the analysis is being performed. The next step shown is the sorting of

this file into sequence by salesman number. The file can then be used to prepare a sales analysis by territory and salesman. Analysis of sales by these two categories may be combined because each salesman only operates within a single territory. Upon completion of this step, the sales summary master is again sorted by customer account number and used to generate a sales analysis by customer or customer class. These various sales analysis reports are provided to the appropriate executives in the marketing department.

Control policies and procedures. A number of control policies and procedures should be integrated into the computerized processing of sales orders. Two examples which have already been mentioned are the key verification of punched cards prepared from sales orders and the use of batch totals. Several other examples may be cited. In the area of data security, all tape files should have both internal and external labels to assure that no file will be inadvertently processed by the wrong program. Tape file protection rings should be removed from all tapes which are to be saved for subsequent processing, in order to prevent such tapes from being written on. These controls apply to the three primary master tapes, the daily shipments and backorders tapes, and the weekly shipments tape. The grandfather-father-son concept should be applied by maintaining a grandfather copy of each of the three master file tapes until a son file is successfully generated from the father file. The card or tape files with which each grandfather file was updated must also be retained so that the father file may be reconstructed if necessary. All of these master and transaction tapes should be stored in a tape library when not in use, and removed only for authorized purposes. Because of its critical nature, a duplicate copy of the current accounts receivable master may be prepared and stored separately.

In the area of processing controls, input validation routines should be included in each file maintenance program in the system. Examples of the edit checks which might be included in these routines are: field checks on all numeric fields in the input data; sequence checks of the input records; validity checks on customer account number, inventory stock number, and salesman number; and reasonableness tests of price and quantity data from the orders. The list of error transactions produced by each file maintenance run should be reviewed by data control or supervisory personnel, and each error transaction should be corrected and resubmitted into the system.

Variations from the basic transactions, such as new customer accounts, sales returns and allowances, or corrections and adjustments of file records, would normally be included in the regular file processing runs. Keypunching personnel should check for the appropriate approval on source documents for transactions of this type. Input records for these items would include a transaction code identifying the nature of each record for the program. Each updating program would then check for and report any records having invalid transaction codes.

Use of disk files. If the three master files in this system for batch processing of sales orders were maintained on magnetic disk rather than magnetic tape, sever-

al of the processing steps in the system could be simplified. For example, all three of the master files could be updated in a single processing run ÷ one of them sequentially and the other two randomly using the random access feature of the disk. Similarly, the sales summary master file could be maintained on disk with three separate indexes – one to customer account numbers, one to salesman numbers, and one to inventory stock numbers. Since the indexes would be in sequential order (though the data are not), the various sales analysis reports could be produced without the need for intermediate sorting steps.

A third efficiency which is facilitated with disk files is called *spooling* and involves processing runs which print more than one type of output report or document. Several examples of such runs appear in the flowchart of Fig. 12.12. Spooling involves writing the information for one report onto the disk file instead of onto the printer during processing. When the processing is completed, the first report or set of documents is removed from the printer and the second is written out from the disk onto the printer. Efficiency is increased by having only one printer tied up by the run instead of two.

A Real-Time System

A system flowchart of a real-time sales order processing system is illustrated in Fig. 12.13. The general characteristics of this system were described in Chapter 7 and will be reviewed only briefly here. This section will emphasize the differences between the real-time and batch processing systems and will also describe control procedures and techniques appropriate for the real-time system.

As shown in the flowchart, a salesman using the real-time system may obtain access to the system from the field, either through his own portable terminal or through regional centers. The salesman may check the availability of inventory items for the customer, check the customer's credit and the status of his account, initiate a transaction, and confirm the transaction immediately to the customer. A shipping copy of the invoice is quickly transmitted to a terminal in the stockroom or a warehouse if prompt shipment is desired. The transaction is immediately posted to each of the four online files. Marketing executives may obtain access to the up-to-date information in these files at any time through one or more terminals in the marketing department.

The flowchart indicates that the system prints out one major document, the invoice, and three major sets of reports. Each of these would probably be spooled on a disk unit and printed out periodically. The invoices for all transactions could probably be printed out once or twice daily. The backorder and shortage list might be printed out several times a day, depending upon how serious the out-of-stock condition is considered to be. The various sales analysis reports might be printed once a week, as before, or possibly once a month. The lesser frequency of need for this report is made possible by the fact that marketing executives have access to the sales summary file at all times. Finally,

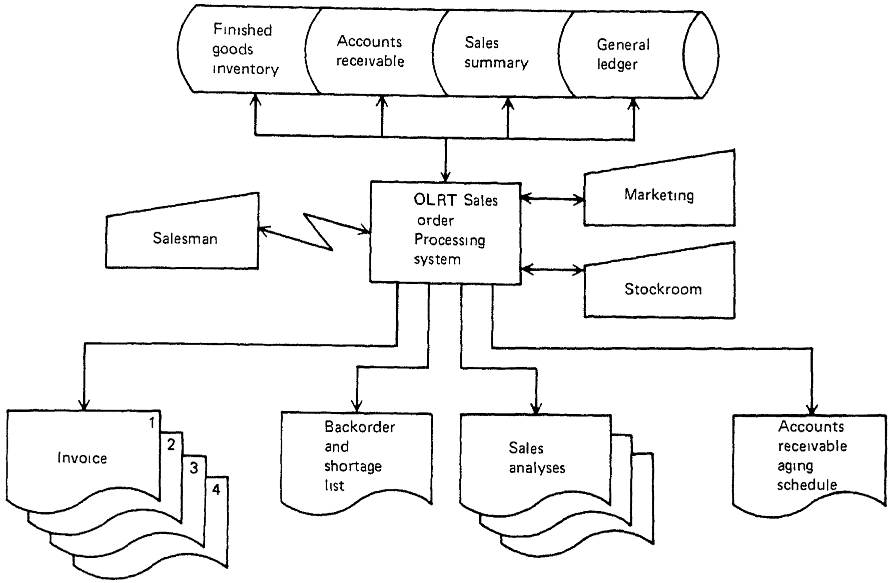


Fig. 12.13 Real-time sales order processing system.

the accounts receivable aging schedule would probably be printed out monthly. If it were deemed useful, credit personnel could also be provided with a terminal from which access to the current file information could be obtained.

This example illustrates some of the major differences between batch processing and real-time systems. In the batch processing system, entering data into the system requires several steps. First, the source document, the sales order, has to be prepared, approved by the credit department, used by the finished goods storeroom personnel in retrieving the goods for shipment, and finally used as a source document for keypunching and verifying shipment and backorder cards. Once the data are recorded on machine readable media (cards or tape), they must be sorted and read in separately for each separate file update. The existence of these several steps in the batch processing system means that (1) there are several possibilities for errors to occur, and (2) the entire process consumes a sizable quantity of time.

In contrast, the real-time system replaces document preparation, keypunching, sorting, and reading with a single step – the keying of the relevant data into the system using a terminal. Credit checking is done automatically and all of the files are updated in one process, without reloading and resorting of tapes. The general ledger is also updated in this process, with no separate procedures being required. Basically, the real-time system accomplishes, in a single automatic process, the same result that requires several different steps, all requiring manual intervention, in the batch processing system.

The real-time system does have a major disadvantage with respect to control of data accuracy: there is only one point in the system at which the accuracy of data can be controlled – the point of entry of data into the system. If the system accepts inaccurate data, the chance to discover and correct the error before it contaminates all files, documents, and reports is lost. However, in another sense this fact is an advantage. It means that control of data accuracy can be focused at a single point, the point of data entry, with the assurance that if all errors are prevented there, no subsequent errors are likely.

The first essential control feature of a real-time sales order processing system is the assignment of a unique user code to each salesman. The user code number of each salesman should be known only to him. Each time the salesman desires access to the system, his user code number is the first item of data he must enter. The system should check the validity of the user code number before accepting any further instructions or data from the salesman. Furthermore, each salesman's user code number should contain an internal code which defines the transactions he is authorized to initiate and the files to which he is authorized to have access. A salesman should be restricted to initiating only sales orders and inquiring only into the accounts receivable and finished goods inventory files.

2 Another control feature over data entry into a real-time system is simplicity of operator data entry procedures. This might be effected by displaying an invoice format for the salesman to fill in, or by writing questions on the terminal which ask the salesman for each required item of data. The system thereby guides the salesman through the data entry process, and will not accept the order until all of the required data have been entered.

One major form of data control which is lost in a real-time system is the batch total. Since transactions are entered one at a time as they occur, there is no such thing as a batch of input records in a real-time system. Responsibility for controlling the accuracy of data input in a real-time system therefore shifts more heavily to data editing routines programmed into the system. With respect to sales order data, the first of these should be a validity check on the customer account number and on the inventory stock number of each item ordered. The system should accept orders from new customers to whom no account number has been assigned, but should not initiate shipping papers until a credit check is performed.

To assure that the salesman does not enter a valid but incorrect account number or stock number, a redundant data check may be used. This would require that the salesman also enter the first few letters of the customer name and the item description. The system could then check whether the number and letters provided by the salesman match with those in the customer account record and the inventory stock record. Alternatively, closed loop verification could be used for this purpose. Given only the account number and item numbers, the system could retrieve the customer name and item descriptions from the files and display these data back to the salesman's terminal for verification.

Another type of edit routine in this system would be a field check to assure that the quantity and price fields contain numeric data only. In addition, if the salesman enters item prices, the accuracy of the prices entered may be tested by comparing them to the list prices on file in the finished goods inventory master.

The various types of reasonableness tests constitute still another class of input validation checks which may be included in this system. First, the reasonableness of the product relative to the customer might be tested. For example, it would not be reasonable for a men's clothing store to order women's underwear. For another example, the reasonableness of the quantity ordered relative to the product might be tested. An order for a large quantity of a large product, such as 500 magnetic disk drive units, would not be reasonable. Conversely, an order for a very small quantity of a small product, such as ten punched cards, would not be reasonable.

If any of these editing routines detect a possible error, the salesman is requested to reenter the item in question. After all data have been entered and have passed the various edit routines, the system may print or display critical data back to the salesman, requesting his verification of its accuracy. This step would detect data transmission errors where the data were entered correctly, but were incorrectly transmitted to the system.

The design of a system of editing routines requires ingenuity and care. All of the techniques described above would not necessarily be appropriate for a given user. The system designed must balance cost and risk factors to decide what is appropriate for the organization using the system.

Still another aspect of the overall control of the real-time sales order processing system involves the maintenance of a transaction log. Such a log is useful for audit purposes and because it enables reconstruction of the files in the event of their accidental destruction. The transaction log could be maintained on a separate disk unit or on magnetic tape, and would be printed out periodically. The master file data would also be periodically written onto magnetic tape. Therefore if any portion of the disk file were destroyed, it could be reconstructed using the most recent tape listing of the file and the transaction log.

REVIEW QUESTIONS

1. Define the following terms:

sales analysis	stock status report
profitability analysis	extensions
subrecord	packing slip
backorder	spooling

2. Describe or illustrate an example of a typical marketing organization structure. Why is an understanding of the marketing organization structure necessary to the analysis of marketing information systems?

3. Describe the decision responsibilities and information requirements of
   a) the Top Marketing Executive,
   b) the Director of Sales,
   c) the Director of Advertising and Promotion,
   d) the Director of Product Planning,
   e) the Director of Customer Service, and
   f) the Director of Marketing Research.
4. Describe the nature of the marketing information provided, and the related data sources used, by
   a) the Accounting Information System,
   b) the Marketing Department,
   c) other sources of information within the business organization, and
   d) external information sources.
5. Describe in detail the data recorded on a sales invoice.
6. Describe in detail the data recorded on a salesman's call report.
7. What are the accounting journal entries which summarize the activities involved in the processing of sales transactions?
8. What are the primary master files which must be maintained in the processing of sales and related transactions? Describe the data content and organization of each.
9. Describe the nature and purpose of a journal voucher.
10. What departments in a manufacturing company might be involved in the manual processing of sales and maintenance of accounts receivable? What documents might be involved and what information would each contain? Where would each originate and to whom would it be distributed?
11. What control procedures are involved in manual processing of sales orders and accounts receivable in a typical manufacturing company?
12. What procedures might be established for handling backordered goods in a manual data processing system? In a computerized data processing system?
13. How is organizational independence achieved with respect to sales order and accounts receivable processing?
14. Describe an appropriate set of procedures for processing sales returns and allowances.
15. Describe the similarities and differences in processing of sales order transactions in a typical manufacturing company using a computer rather than a manual data processing system. Emphasize documents, departments, and reports involved in the process.
16. What control procedures might be involved in batch processing of sales transactions by a typical manufacturing company using a computer data processing system?

17. If the sales summary file is maintained on magnetic tape, why are three separate sorts necessary to generate sales analyses by product, by salesman, and by customer? How can these sorts be avoided if the file is maintained on magnetic disk?
18. Describe three means of simplifying a computer based system for batch processing of sales orders if magnetic disks are used to store master files instead of magnetic tapes.
19. Prepare a system flowchart of a real-time system for processing sales orders.
20. Describe some of the major differences between a computerized batch processing system and a real-time system for processing sales orders.
21. Describe several control procedures and techniques appropriate for a real-time sales order processing system. What is the major difference in emphasis between these techniques and those in a batch processing system?

DISCUSSION QUESTIONS

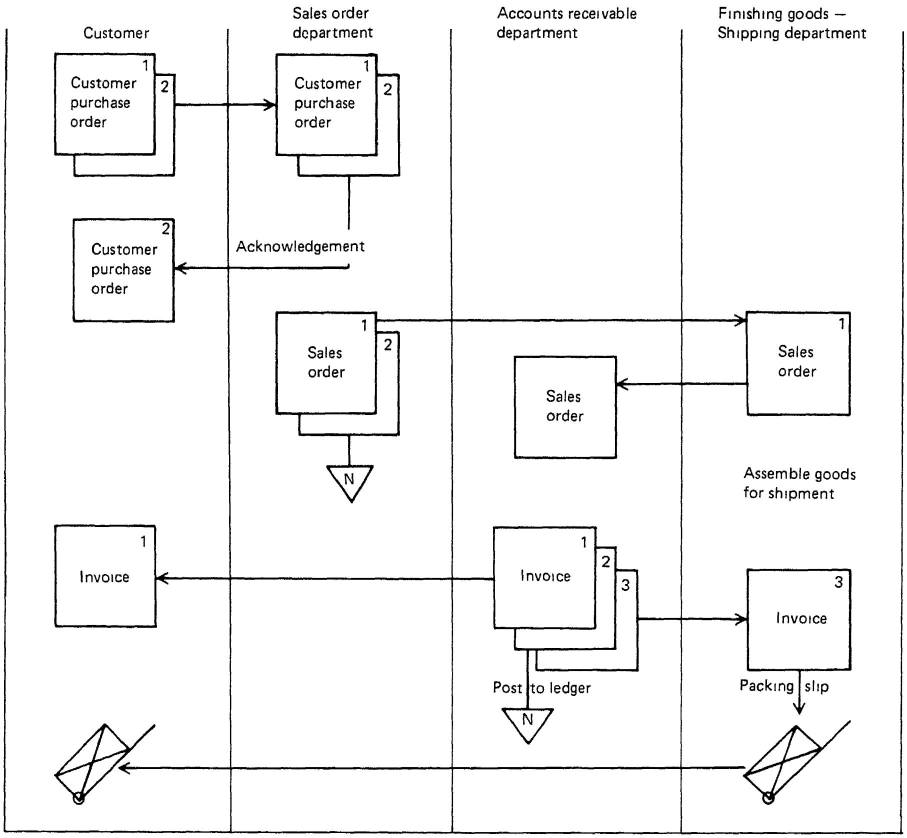
22. This chapter primarily emphasized the marketing information requirements of a manufacturing firm with a large sales force. Compare the organizational structure, information requirements, and data sources of this type of organization with those of
    a) a large retail organization,
    b) a firm which does all selling by direct mail,
    c) a large motel chain, and
    d) a hospital.
23. Some companies have created the post of Product Line Manager within the Marketing Department. There may be several Product Line Managers, each responsible for a related group of products. Discuss the effects on decision responsibilities and information requirements within the Marketing Department of this type of organization.
24. Create a definition for the term "marketing information system." Discuss the conceptual and operational relationships between marketing information systems and accounting information systems.

PROBLEMS AND CASES

25. As a systems analyst for the Dolphin Motor Company, you have been asked to design a computer report which will analyze product sales by dealers. The company sells three major lines of cars – the Dolphin, the Eagle, and the Flyer – and all dealers carry all three lines. Assume that space constraints limit the report such that a maximum of eight columns of data may be placed across the width of a page. Of course there are no constraints regarding how many lines of data may be used for each dealer.

In designing the report, you may make any reasonable assumptions about the availability of data. Make sure that you take into account the need for effective presentation of information, the need for standards of comparison, and the principle of management by exception.

26. Shown below is a document flowchart of sales order, billing, and accounts receivable procedures (including everything except cash receipts) for Tabco Manufacturing, Inc. What changes would you recommend to improve control and efficiency?



27. What controls in a sales order processing system are designed to provide the best protection against the following errors or manipulations?

a) Theft of goods by shipping department personnel, who claim that subsequent shortages are due to errors made by personnel in the finished goods storeroom.
b) An error in posting from a copy of an invoice to the accounts receivable ledger.
c) Sale to a customer who is four months behind in making payments on his account.

d) Billing a customer for the quantity of raw materials ordered, when the quantity shipped was actually less than the quantity ordered due to an out-of-stock condition.

28. Transitron Enterprises is a manufacturer of a variety of electronic components. Its customers are well-established and sophisticated producers of industrial and consumer electronic products. The market for all of Transitron's products is very competitive.

    Transitron will soon acquire a more advanced computer system which includes direct access storage and remote terminals. One application which is being substantially revised due to this acquisition is the processing of sales transactions. Previously both the accounts receivable file and the finished goods inventory file were stored on sequential access media, and so updating these files for sales transactions had to be done in two separate runs. Now one of these files will be maintained on direct access storage and sales transactions will be able to be processed against both files in one run.

    a) What data should be included on an input record for a sales transaction?
    b) Which of the two files would you recommend be stored on the direct access device and why?
    c) Assume that the input record for a sale is on punched cards and that one report which should be produced is a listing of finished goods items whose balances drop below a "danger point." Draw a systems flowchart of the integrated file update process as described.

29. Cragg and Company utilizes a real-time sales order processing system. Sales orders are entered into the system by salesmen utilizing portable data terminals from customer offices. For each sale, the salesman enters his salesman user code number, the customer's account number, and the item number, quantity ordered, and price of each item sold.

    Required:

    Describe several means by which the system should be programmed to check the accuracy and validity of the input data entered by salesmen. Relate your answer specifically to the data items mentioned.

30. The Rigby Company has twelve major product lines with twenty to thirty items in each product line. Product Line Managers have been selected to assume product planning responsibilities for each product line. As a systems analyst in charge of designing marketing information systems, you wish to show these Product Line Managers the kind of information that can be made available to them.

    Required:

    Design a computerized sales analysis report which analyzes sales by product item within each product line. Assume that space constraints limit the

report such that a maximum of eight columns of data may be placed across the width of a page. In designing the report, you may make any reasonable assumptions about the availability of data. Make sure that you take into account the need for effective presentation of information, the need for standards of comparison, and the principle of management by exception.

31. Elite Publishing Company has established a subsidiary, Businessman's Book Club, Inc. (BBC) which will operate as described below.

BBC's editors will select from among recently published books in the business area those which it feels will be of most interest to businessmen. These books can be purchased in large lots at approximately 40% of list price. BBC plans to sell these books to its club members at approximately 75% of list price.

Solicitation of new customers will be done through advertising by direct mail and in selected publications. Such advertisements will offer four free books if one is purchased and if the purchaser agrees to become a member of the club. Each club member will be sent a list of new selections each month. Members are not required to buy any books. After purchase of four books a member is sent a list of selections from which he may choose a free book.

You have been called upon to design a computerized billing and book inventory system for BBC. Assume that you have asked various managers about their information needs and find that: the advertising manager wants to know which advertising media are more effective, the credit manager wants to know which accounts are more than 90 days past due, and the editors want to know which books are best-selling.

Required:

a) Identify the master files which you feel should be maintained in this system and list the data content of each.
b) Identify the input transactions which it will be necessary for this system to process, and the output documents and reports which the system must be designed to produce.
c) Assume that transaction inputs will be on punched cards, and that one of the master files in part (a) may be stored on a magnetic disk unit, while any others are to be stored on magnetic tape. Prepare systems flowcharts of all computer runs necessary to process the inputs, maintain the master files, and generate the outputs for your system.

Chapter 13

Accounting Information Systems for Logistics Management I

Logistics management involves planning and controlling the physical flow of materials through an organization. In most cases these materials are inventories — either product inventories in a retail organization, or inventories in various stages of production in a manufacturing organization. In some firms — transportation companies are a good example — the materials with which logistics management is concerned are fixed assets, such as jet planes, railroad cars, or taxicabs. In still other cases involving service organizations such as professional accounting firms, the primary logistics problems relate to the assignment of personnel. Construction companies may have the most complex logistics problems of all, for they must plan and control the flow of inventories, assets, *and* personnel between various construction sites.

The information requirements of the logistics management function are the subject of this and the following chapter. From the above discussion, the difficulty of generalization with respect to logistics management should be evident. However, for the sake of simplicity, these chapters will focus upon the most common and familiar example of logistics management — the production operations of a typical manufacturing company. As a starting point for this approach, Fig. 13.1 illustrates the organization structure of the production department of a typical manufacturing company.

The logistics function is very closely interrelated with the marketing, personnel, and finance functions in most organizations. These interrelationships are manifested by numerous shared data bases and interdepartmental communication flows. Simplicity of presentation demands that the logistics function be examined separately from the other functions, which unfortunately tends to deemphasize the significance of such interrelationships. The reader should be alert to the evidence of these interrelationships as he proceeds through this and the other chapters in Part Four.

The logistics management function may be divided into two subfunctions, which are (1) purchasing and inventory management, and (2) production management. Purchasing and inventory management, the subject of this chapter, is

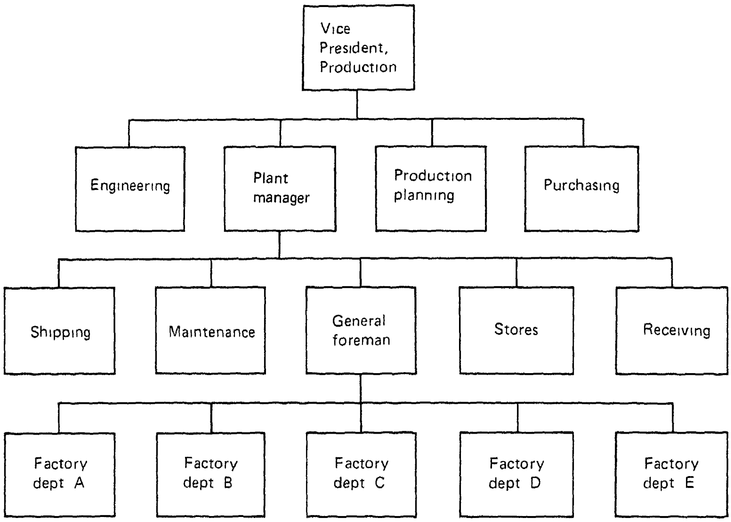


Fig. 13.1 Production department organization.

relevant to retail organizations as well as to manufacturing firms. Production management and its related information flows is the subject of Chapter 14.

THE PURCHASING AND INVENTORY MANAGEMENT SYSTEM

The Purchasing Function

The purchasing function is the primary management function in the purchasing and inventory management system. The basic decisions for which the purchasing department is responsible include (1) the quantity to be purchased, (2) the timing of purchases, and (3) the vendor from whom to purchase.

Deciding upon the quantity and timing of each item purchased is called the inventory control function, and was discussed briefly in Chapter 3 as an example of a feedback control system. The inventory control function has been the frequent subject of applications of mathematical modeling techniques. The basic objective is to determine for each inventory item the order quantity and reorder point which minimizes the sum of the costs of ordering the item, carrying the item in inventory, and being out of stock. Application of the mathematical models requires that these three cost factors be quantified, that the future requirements for the item be known or estimated, and that an estimate of vendor lead time be prepared.[1]

[1]For an extensive coverage of mathematical modeling techniques of inventory control, see Harvey M. Wagner, *Principles of Operations Research* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1969), Chapter 19.

The information required for estimating future requirements for an item and vendor lead time can be generated by formal information systems within an organization. In a retail organization, future demand can be estimated by applying forecasting techniques to historical records of past sales. In a manufacturing organization, future requirements can be determined if a sophisticated system of production planning is used. Vendor lead time can be estimated if formal records of past dealings with vendors are maintained.

Inventory costs are generally the most difficult elements of the model to estimate. Carrying costs include all costs which vary with the quantity of goods in inventory. The most significant element of carrying cost is the opportunity cost of the funds tied up in inventory. Stated another way, this cost represents the revenue lost from investing funds in inventory rather than in revenue generating activities. Other elements of inventory carrying cost include the incremental costs of spoilage, breakage, pilferage, obsolescence, insurance, taxes, and space utilization. Ordering cost refers to only those costs which vary with the number of orders placed, and generally involves the costs of processing the order and the fixed costs of shipping. Stockout cost, which involves lost goodwill or inefficiencies in operations, is practically impossible to measure, and is therefore usually the subject of arbitrary estimates.

In general mathematical modeling techniques are only applied to the high-cost, high-usage items of inventory. For low-cost, low-usage items, carrying and ordering costs are so insignificant that reorder point and order quantity can be set with the sole objective of eliminating stockouts. Once the order quantity and reorder point of an item are determined, they are stored along with other data pertaining to the item in the master inventory file. Clerks or machines then are responsible for applying these policies to determine the timing and size of individual orders.

The other significant management decision made by the purchasing function is selection of vendors for inventory items. In a retail organization, there are buyers who specialize in related lines of merchandise. When the decision is made to carry a particular type of merchandise in the store, it becomes the buyer's responsibility to select a supplier. Examples of factors relevant to the decision are price, reliability, product styling, brand image, and quality. Information on prices and styles is provided by representatives of the various suppliers. Information on brand image and quality should be known to the buyer from his knowledge about the lines of merchandise in which he specializes. Information on reliability – the supplier's history of meeting quantity specifications and delivering goods promptly – should be maintained as part of a vendor history file within the purchasing department.

In a manufacturing organization, the selection of vendors for raw materials is made when the engineering department provides the specifications for a new part to the purchasing department. Purchasing then prepares requests for price quotations which are sent to potential suppliers. Once these price quotations are received, the purchasing department selects a vendor for the item. The decision is based not only on price, but also on reliability, quality, and perhaps whether a given supplier is also a significant customer. Records of dealings

with vendors should be maintained to provide information about reliability, and product quality. The quality of a vendor's products can be measured in terms of how frequently products received from the vendor fail to pass inspection or testing performed by the receiving department.

Once a vendor has been selected for a product, the identity of that vendor becomes a part of the master inventory record of that product. Vendor selection thus does not have to be performed each time the product is ordered. How ever, the identity of possible alternative vendors may also be included in the file, in case the primary vendor is temporarily out of stock. Periodically decisions may be made to change primary vendors for some products if a primary vendor does not provide satisfactory service or goes out of business.

The Accounting Transactions

The basic accounting journal entries which summarize the purchasing process vary depending upon whether the firm uses a perpetual or periodic inventory accounting system. In a perpetual system one basic entry is used to record purchases:

Raw Materials Inventory	XXX	
Accounts Payable		XXX

Purchase returns and allowances are reflected as a reversal of that entry. If inventory counts reveal that actual quantity on hand is less than the quantity recorded, the Raw Materials Inventory account is written down and the debit entered to Cost of Goods Sold or to a special loss account.

If a periodic inventory system is used, purchases are recorded by the following journal entry:

Purchases	XXX	
Accounts Payable		XXX

Purchase returns and allowances are recorded in a special contra-account as follows:

Accounts Payable	XXX	
Purchases Returns and Allowances		XXX

Periodically a complete physical inventory is taken, and the following journal entry is made:

Inventory (Ending)	XXX	
Cost of Goods Sold	XXX	
Purchases		XXX
Inventory (Beginning)		XXX

This entry adjusts the inventory balance to its correct level and records Cost of Goods Sold for the period as the total of Purchases for the period plus the net reduction (or minus the net increase) in the Inventory account.

The Master Files

Four major master files may be maintained as part of the processing of purchase transactions. These are (1) a raw materials inventory file, (2) an accounts payable file, (3) a file of open purchase orders, and (4) a vendor history file. Of course, some organizations may not find it essential or desirable to maintain all of these files. This section reviews the data content and organization of these various files.

Maintenance of a raw materials inventory master file may be the responsibility of the accounting department or production department in a manual system, or of the data processing section in an automated system. In a manual system, the raw materials master is commonly maintained on materials ledger cards such as that shown in Fig. 13.2. Note how this ledger card maintains a record of recent transactions pertaining to the item, including issues, receipts, and orders placed, and also a record of the current balances on hand, on order, and available. The balance available is the sum of the on-hand and on-order balances.

In more sophisticated systems, unit cost data for all issues, and receipts, might be maintained in the raw materials inventory file. All receipts would be entered at their purchase cost. All issues would be recorded on a FIFO, average, LIFO, or other cost basis. Such records would be much easier to keep up in automated systems than in manual systems.

In an automated system, the raw materials inventory master would probably be maintained on magnetic tape or disk. The inventory item number would serve as the control field for the file. Each inventory record would contain transaction cost data, in addition to roughly the same data as shown on the ledger card, except that only the most current balances would be included. Each recent transaction involving an item would be stored as a subrecord of that item. Each subrecord could be retained for as long as necessary and then erased.

Basic input transactions from which the raw materials inventory master is updated include receipts of materials from vendors, issues of materials into production, and purchase orders. The file itself is an important reference for personnel in production planning, purchasing, and production operations. Possible output reports generated from this file include the stock status report, exception reports on high and low activity items, and requisitions to purchase additional quantities of low balance items. In some automated systems, the purchase order may be prepared as a by-product of the updating of this file.

The typical data content and organization of a record in an accounts payable master file is shown in Fig. 13.3. The heart of each record is a set of subrecords, each containing the data from a disbursement voucher. In turn, each disbursement voucher represents an authorization to pay a vendor invoice. In a manual system, the file may consist of a set of ledger cards, each including records of paid vouchers and payments made in addition to vouchers currently due. Alternatively, the file may consist simply of all unpaid vouchers, with the voucher number as the control field.

MATERIALS LEDGER CARD					
Item number 5216408		Description bearing			Reorder point. 150
Location		Standard unit cost	Vendor		Order quantity
Row 26	Bin 12	$1 40	Code 3621	Name Needmore Mfg	500

Transactions						Balances		
Date	Reference		Issued	Rec'd	Ordered	On hand	On order	Available
1/2/73	P O	1008			500	0	500	500
1/7/73	Rec	1095		300		300	200	500
1/9/73	Req	1056	200			100	200	300
1/14/73	Rec	1208		200		300	0	300
2/4/73	Req	1128	200			100	0	100
2/9/73	P O	1101			500	100	500	600
2/16/73	Rec	1375		500		600	0	600

Fig. 13.2 Sample materials ledger card.

Vendor number (control field)
Vendor name and address
Vouchers payable
  Voucher number
  Vendor's invoice number
  Date payment due
  Invoice amount
  Discount
Total Account Balance

Fig. 13.3 Example of data content and organization of accounts payable record.

The basic input transactions to the accounts payable master file are disbursement vouchers. Other transactions which update the file include debit

NEEDMORE MANUFACTURING COMPANY

PURCHASE ORDER
987 Glendale
Needmore, Texas 78799
No 12153

TO
Avalon Electronics
401 Cherry Street
Waco, Texas 78123

Show the above order number on all invoices and shipping papers

Vendor number	Order date	Req number	Buyer	Terms
8015	3 14-73	27654	Dave Watson	2/10

F O B	Ship via	Deliver on	Remarks
Shipping point	express	At once	

Item no	Part number	Quantity	Description	Price
1	86402	20	Transistor	$1 44
2	78712	20	Diode	1 65
3	81296	10	Capacitor	2 40

Buyer ____________

Fig. 13.4 Sample purchase order.

memos for purchase returns and allowances, additions of new vendor accounts to the file, and miscellaneous corrections and adjustments. The basic output documents generated from the file are checks in payment of vendor invoices. One important output report prepared from this file is a summary of short-run cash requirements which indicates the total of cash payment commitments for several days into the future.

The file of open purchase orders contains a record of all purchase orders made by the organization which have not yet been completely filled. In a manual system, this file would consist simply of purchase order documents, such as the one illustrated in Fig. 13.4. In an automated system in which the open purchase order file is maintained on magnetic tape or disk, each record would contain basically the same data as the purchase order document. The order number would serve as the control field and the data pertaining to each item ordered would comprise a subrecord of each order record.

Basic inputs to the open purchase order file are new orders placed and receipts of goods on order. If partial shipment is received, a notation of the receipt may be posted to the appropriate file record. Once a purchase order

is completely filled, it should be removed from the open purchase order file. The file itself provides an important source of information for purchasing, accounting, and production personnel. Output reports which might be generated from processing of this file include short-run cash flow commitments schedules and lists of orders for which delivery is past due.

The vendor history file uses the vendor number as its control field. The exact data content and organization of a record in this file will vary considerably in practice. Basically, each record should contain: the vendor's name and address; shipping arrangements agreed to with the vendor, including type of carrier; and a summary record of all past dealings with the vendor. This summary record includes price quotations requested, orders awarded, the total dollar amount of all orders placed for the year, late shipments, early shipments, shipments rejected for poor quality, and shipments of the incorrect quantity. All business conducted with a vendor results in the updating of that vendor's summary record on the file. This file is used as a basic reference for vendor selection and evaluation of vendor performance, and may be used to generate reports for these purposes.

A Manual System

The document flowchart of Fig. 13.5 illustrates one example of a manual system for processing purchase transactions in a manufacturing company. Most companies will differ in some respects from this example, but the general pattern of information flow, even in nonmanufacturing organizations, will not vary a great deal from the illustration in most cases.

As the illustration shows, the purchasing process begins with the initiation of a purchase requisition by the inventory clerk. The purchase requisition, illustrated in Fig. 13.6, indicates that the supply of an item of inventory is low and a reorder is necessary. The quantity required and the number of the primary vendor are also indicated. One copy of each requisition prepared is sent to the purchasing department and a second is filed by requisition number by the inventory clerk.

Using the purchase requisitions, the purchasing department prepares purchase orders. In some cases, the purchasing department may utilize a vendor other than the primary vendor, or may change the order quantity to comply with the vendor's shipping quantity per package. Several copies of each purchase order are prepared. Two are generally sent to the vendor, with the request that one be returned as an acknowledgment. At least one copy is filed in the purchasing department, and other copies may be sent to the inventory clerk, accounts payable, and receiving.

The purchasing department records the receipt of acknowledgments from vendors, and also the receipts of items ordered, in the open purchase order file. Purchasing department personnel are responsible for following up on orders for which no acknowledgment has been received or for which delivery is overdue.

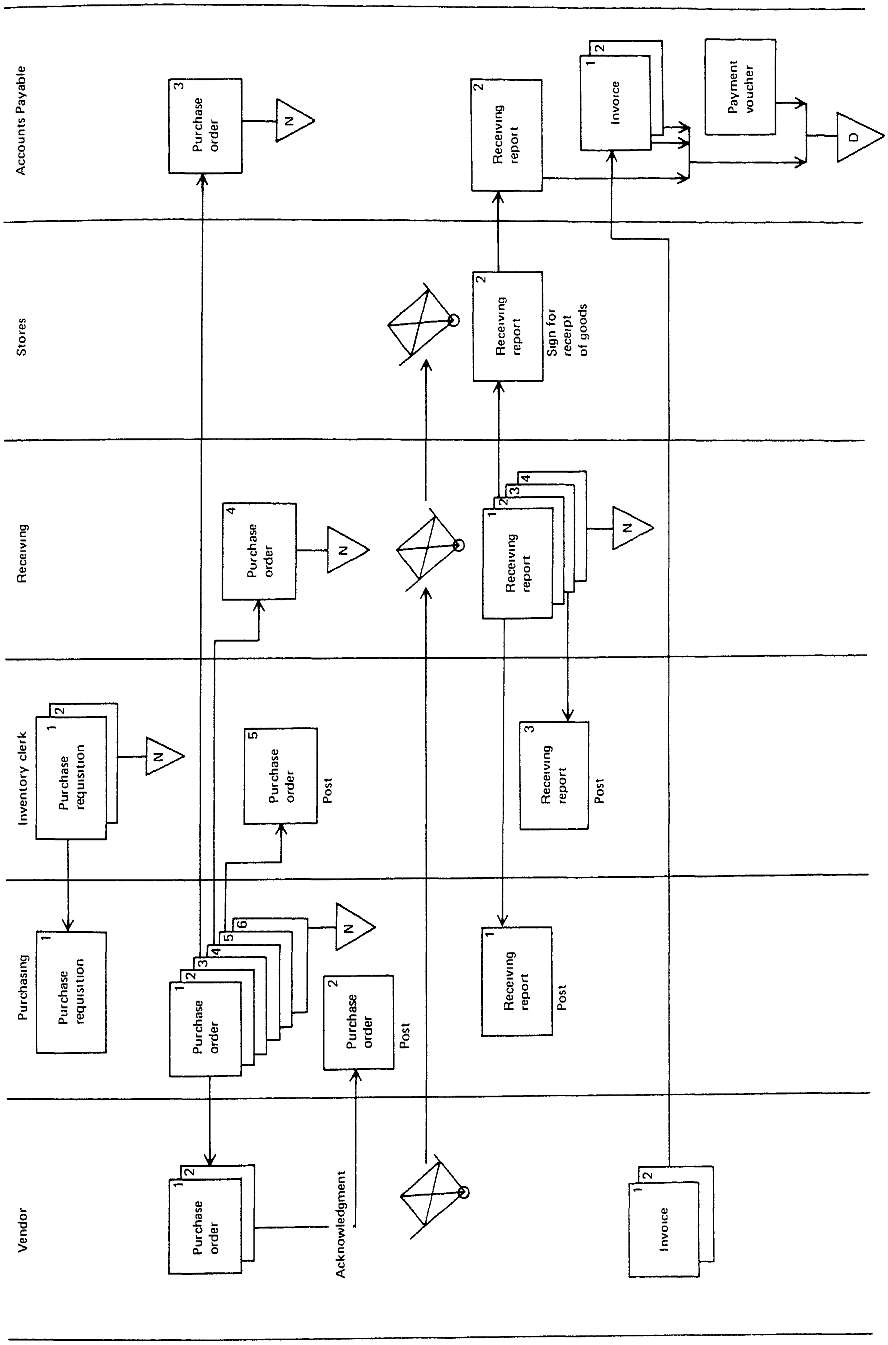


Fig. 13.5 Document flow in a manual system for processing purchase transactions.

NEEDMORE MANUFACTURING COMPANY — Req No 1245

PURCHASE REQUISITION — Date 2/10/73

Date needed	Vendor code	Prepared by	Department
2/15/73	3725	J Trimble	Stores

Part number	Quantity	Description	Quantity on hand	Reorder point	Reorder quantity
72142	450	Shaft	40	100	400

Fig. 13.6 Sample purchase requisition.

In the event that goods received are damaged or do not pass quality inspection, the receiving report will so indicate, and the purchasing department must correspond with the vendor to arrange an appropriate adjustment.

Another copy of the purchase order is provided to the inventory clerk for posting to the "on order" field of the raw materials inventory records. Still another copy should be provided to the receiving department. This copy is filed by purchase order number and checked by receiving personnel when the goods are received to verify that the goods were actually ordered. For control purposes, the quantity ordered should not be included on this copy. This will encourage the receiving department personnel to carefully count the quantity of each item received.

When the goods are received by the receiving department, a document recording the receipt is prepared. An example of this document, called a receiving report, is illustrated in Fig. 13.7. Inspectors in the receiving department examine the goods for damage or poor quality, and an indication of acceptance or rejection of the goods is made on the receiving report. The receiving department files one copy of each receiving report by its document number. Another copy is routed to the purchasing department for posting to the open purchase order file. Still another copy is sent to the inventory clerk, where it is posted to the master inventory file. The receipt will increase the quantity on hand in the file and decrease the quantity on order. A final copy accompanies the goods to the storeroom and then is sent to the accounts payable department.

The transfer of custody of goods from the receiving department to the parts storeroom is a significant event for control purposes. The transfer of accounting control for the goods should be evidenced by the signature of stores personnel on the copy of the receiving report. Stores personnel must

RECEIVING REPORT No 6405			
Prepared by	Date	"P O " number	Vendor

Quantity	Units	Description
Delivered by		Inspected by ________ Remarks
Shipping weight		

Fig. 13.7 Sample receiving report.

verify that the correct items have been received in the appropriate quantities prior to signing the receiving report, because they are responsible for subsequent shortages. The signed copy of the receiving report is immediately routed to the accounts payable department. The signature assures the accounts payable personnel that the goods for which they approve payment are safely in the custody of storeroom personnel.

The accounts payable department receives vendor invoices requesting payment for goods delivered. Before approving these invoices for payment, accounts payable clerks check each one against its corresponding receiving report and purchase order. The department maintains its own file of open purchase orders for this purpose. The purchase order is checked to assure that the goods were ordered and that the quantities received and prices charged are consistent with the order. If the shipment is a partial shipment, the quantity received is posted to the purchase order. The receiving report is checked to assure that the quantities received are equal to the quantities invoiced. The accuracy of the extensions on the vendor's invoice must be verified. Once all of these steps have been completed, a voucher is prepared which authorizes the cash disbursement in payment of the invoice. These documents are then filed according to the due date of the invoice. Cash disbursement procedures are discussed in Chapter 16.

Organizational independence with respect to the purchasing function is achieved by separation of the operating function performed by the purchasing department from the custodial functions performed by the receiving and stores department. Furthermore, both of these functions are separated from the recording functions performed by the accounts payable department and the

inventory clerk. This separation helps to assure that all goods which are ordered are actually received and are properly and accurately recorded.

Another significant control procedure with respect to raw material inventories is the reconciliation of actual inventory quantities with the inventory records. This may be done on a periodic basis, with high-cost and high-usage items being reconciled more frequently than low-cost, low-usage items. In addition this reconciliation should also be performed whenever it becomes obvious that there is a discrepancy; for example, when the inventory record shows a negative balance or when no parts are available even though the record shows a positive balance. These reconciliations should be performed by accounting department personnel, perhaps internal auditors, who are independent of both inventory record keeping and stores.

The control policies exercised with respect to the purchasing operation and personnel are also important. Budgetary control over the cost of purchased raw materials might be achieved by a standard cost system in which the purchase price variance is the responsibility of the purchasing department head. Budgetary control over the purchase of supplies, or of merchandise in a retail organization, is often exercised over the department requesting the supplies or merchandise rather than over purchasing. To control the possibility that purchasing personnel might favor certain vendors who offer them gifts or kickbacks, a policy that no such gifts may be accepted by purchasing personnel should be enforced. Use of the purchase requisition as the basis for purchase order preparation also provides control in this sense in that the requisition evidences a definite need for the goods by the company. Finally, it may also be a good control policy to require that all purchasing employees involved in vendor selection make known any significant financial interest they may have in supplier companies.

A Computer Based Batch Processing System

A document flowchart of the purchasing process for a typical manufacturing company using a computer based system appears in Fig. 13.8. It is assumed that the system uses punched card input and maintains master files on magnetic tape. The illustration is merely an example rather than a description of the actual system of a real company. Much of the description is also applicable to nonmanufacturing organizations.

A comparison of Fig. 13.8 with its manual counterpart in Fig. 13.5 reveals that the computer has completely replaced the manual system's inventory clerk. However, the functions performed by purchasing, receiving, stores, and accounts payable are very similar in both systems. One minor difference is that the accounts payable department now prepares two copies of the voucher. One is filed in voucher number sequence, with the supporting invoice and receiving report documentation attached. The second copy is provided to the input preparation (keypunching) department as a source document for a computerized cash disbursements system (described in Chapter 16). Another difference is

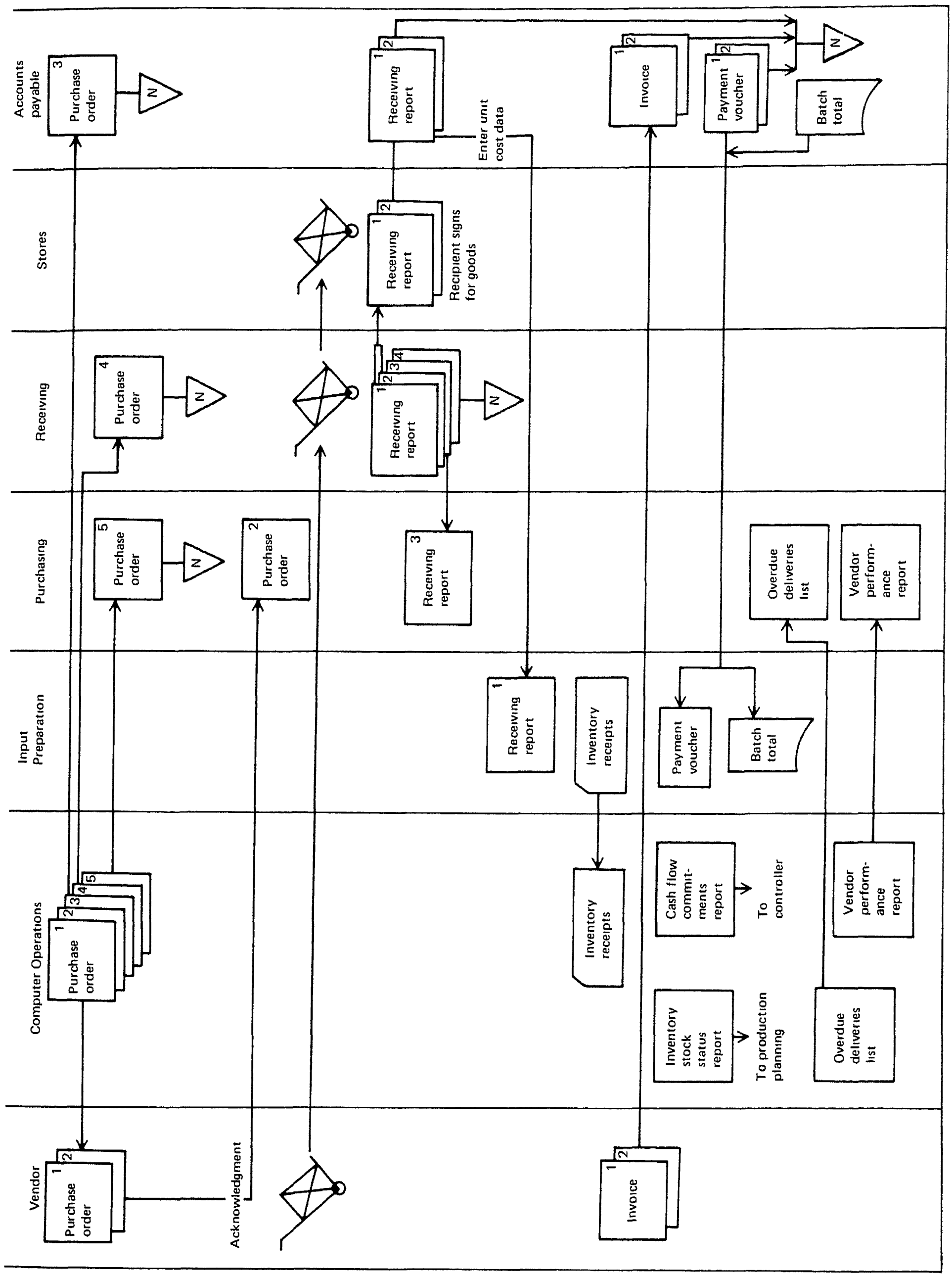


Fig. 13.8 Document flow in computerized batch processing of purchase transactions.

that the computer prepares purchase orders instead of the purchasing department. In addition, the computer generates two reports for the purchasing department and one for the controller which may not have been available in the manual system.

A systems flowchart of the operations involved in the computerized purchasing system appears in Fig. 13.9. For purposes of simplification, the flowchart is separated by dashed lines into four major categories of operations: input preparation and data control, raw materials inventory, purchase order preparation, and weekly report preparation. After coverage of each of these four areas of operation, this section concludes with a discussion of control policies and procedures in the system and possible efficiencies arising from use of magnetic disk storage for master files rather than magnetic tape.

Input preparation and data control. Each day this operation begins with the assembly of inventory transaction source documents in batches and the preparation of batch totals. Note that inventory issues and other inventory transactions are processed along with receipts in one integrated process. The origination of issue documents is covered in Chapter 14.

Control totals which might be obtained for each batch of inventory transactions include record counts of the total number of transactions, the total number of issues, and the total number of receipts, as well as hash totals of all inventory stock numbers, the number of units issued, and the number of units received. These batch totals are retained for comparison with those generated after the inventory update run. If any discrepancies are found in the comparison of batch totals, it may indicate that some records were lost or improperly processed. Subsequent checking in detail of those specific batches for which a discrepancy exists should enable discovery and correction of any errors.

The next step in input preparation is keypunching and key verification of inventory transaction cards from the batched source documents. This is followed by sorting of the cards into inventory item number sequence on a card sorter, after which they are ready for processing against the inventory master. Alternative methods of input preparation include the conversion of the cards to magnetic tape using either an offline converter or a utility routine on the central processor, and the direct encoding from source documents to magnetic tape using a key-to-tape encoder. In either case, the records on magnetic tape would then have to be sorted using a tape sort routine on the central processor prior to processing against the inventory master.

After the inventory transaction cards have been processed to update the raw materials inventory file, they are again processed in preparation for use in other applications. They are first separated into three groups – issues, receipts, and other transactions. A punched card collator is used for this step. Receipt transaction cards are accumulated for a week and then sorted by purchase order number on a card sorter for processing to update the open purchase order file. Though not shown, the issue cards and other transaction cards may also be saved for use in other applications.

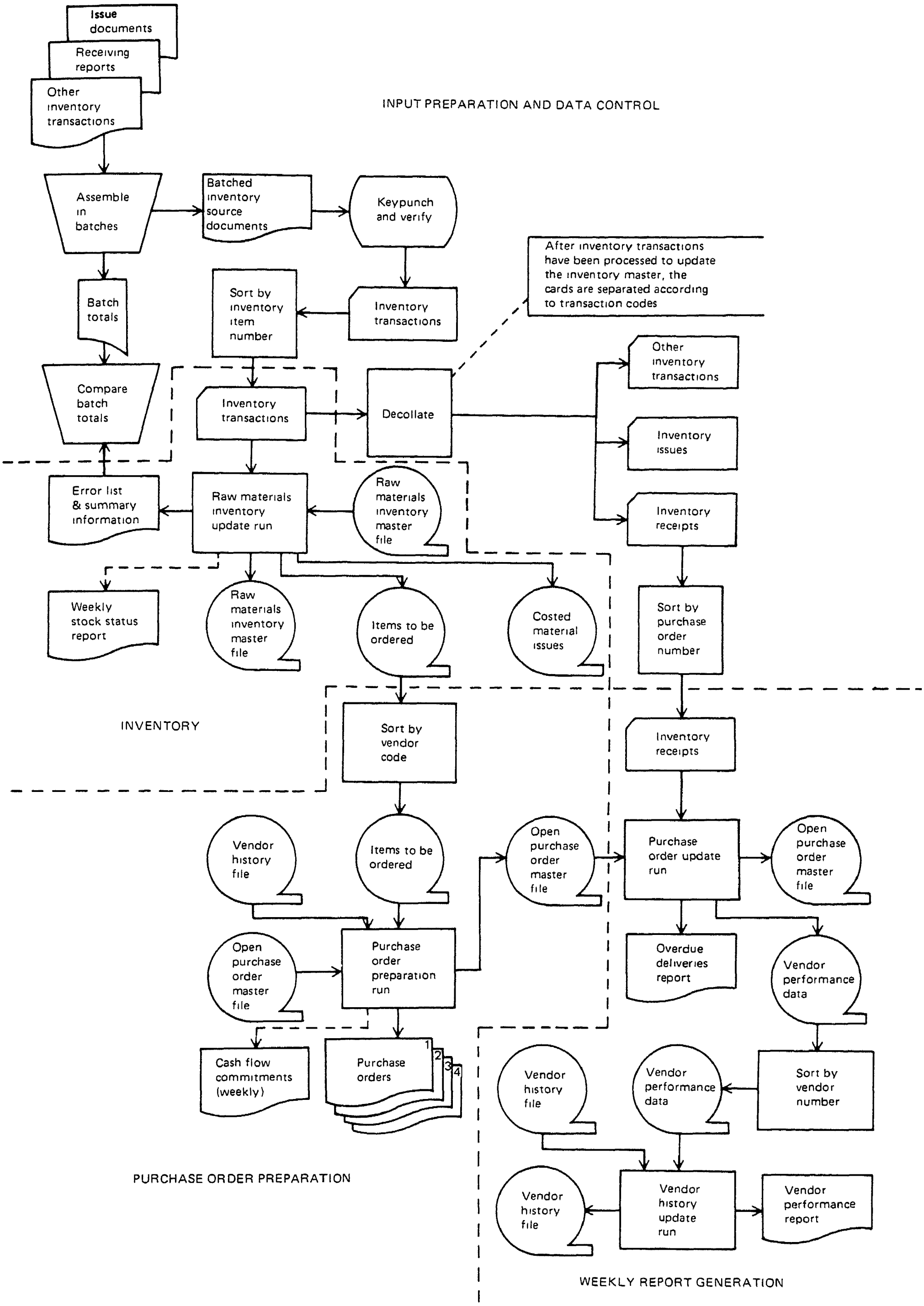


Fig. 13.9 Systems flow in computer based batch processing of purchasing transactions.

Raw materials inventory processing. This step is performed daily and involves only one main updating program. Inputs to the program are the inventory transaction cards and the raw materials inventory master file, both sequenced by inventory stock number. This run updates the inventory master file for all inventory transactions and writes an updated version of the file on magnetic tape. Also prepared are two data tapes – one containing costed material issues and the other a list of items to be reordered. Each record on the costed material issues tape indicates the cost of the item issued into production, determined on a FIFO, LIFO, or other basis from the cost data recorded on the inventory file. This tape is used in a computerized system of accounting for materials costs in production, as explained in Chapter 14. The tape list of items to be reordered includes a record of every inventory item for which the quantity available has fallen below the reorder point. Each record on this list includes the item number, description, vendor code, quantity to be ordered, and price of the item. This "order list" becomes input to the purchase order preparation process. All orders on this list are also posted to the "on order" field of the raw materials inventory file.

Two output reports are also generated by the raw materials inventory updating program. One is a list of error transactions flagged by one or more input validation routines of the update program. This report also contains the batch totals mentioned above and summary journal entries for the inventory transactions, including the debit to raw materials inventory and the credit to accounts payable for inventory receipts. The second output report is a stock status report on the inventory file. The dashed line to this report indicates that this report is only printed once each week, rather than every day. Copies of the stock status report might be provided to stores personnel for reference in storeskeeping operations, and to production planning personnel for use in planning future production.

Purchase order preparation. This process begins with the sorting of the order list into sequence by vendor number. This step is appropriate because several items might be ordered from the same vendor, and such items should all be included on one purchase order. The order list is then processed together with the vendor history file and open purchase order file to prepare purchase orders. For each purchase order, the vendor's name and address, shipping arrangements, and credit terms are pulled from the vendor history file. As described above, the order list includes all data on items ordered for each purchase order. A purchase order number is assigned sequentially according to the next highest number available on the open purchase order master. An original and four copies of each new purchase order are then printed out, and the new purchase order is also added to the open purchase order file. Once each week, a report of short-run cash flow commitments according to the open purchase order master is also printed. This report is provided to the controller or treasurer for use in planning short-run cash flows.

Weekly report generation operations. These operations are performed once each week for the purpose of preparing reports for use in purchasing management. The first step is to update the purchase order master file for receipts of items on order. Quantities received are subtracted from quantities on order in the file, and orders which have been completely filled are removed from the file. In addition to an updated version of the open purchase order master, this computer run generates a report on overdue deliveries and a magnetic tape file of vendor performance data. The overdue deliveries report lists those orders for which the promised or expected delivery date has passed without the order having been received. This report is provided to the purchasing department for their use in following up on these orders. The vendor performance data tape contains current information on each vendor concerning such matters as compliance with requested delivery dates, discrepancies between quantities ordered and quantities received, discrepancies between prices quoted and prices billed, and number of defective pieces received.

The next step in this portion of the process is to sort the vendor performance data tape into sequence by vendor code number. The tape is then processed to update the vendor history file for the current performance factors. This process generates a report of vendor performance, summarizing for each vendor historical and current performance regarding the factors cited above. The vendor performance report is provided to the purchasing department for use in vendor selection.

Control policies and procedures. Among the control policies and procedures which might be used in this system for computerized batch processing of purchasing operations are two which have already been mentioned – key-verification of inventory transaction cards and batch totals. This section will discuss other examples in the areas of data security and input validation.

Data security in this operation primarily involves the master tape files of open purchase orders, raw materials inventory, and vendor history, as well as the transaction tapes of items to be ordered and current vendor performance. Each of these tapes should have appropriate internal and external labels to prevent their being processed by the wrong program or on the wrong date. Tape file protection rings should be removed from these tapes after they are written to prevent the data on them from being written over or erased during subsequent processing. Grandfather versions of each master file tape should be retained together with the transaction cards or tapes by which they were updated until a son file is successfully prepared from the father file. Each of these master and transaction tapes should be stored in a tape library when not in use, and only released for processing when authorized according to the processing schedule or by the data processing manager.

The inventory update program should contain an input validation routine which performs various edit checks on the inventory transactions. These would include a validity check on transaction codes and on the inventory item number

in all issue, receipt, and master record adjustment transactions. Check digit verification might be performed on stock numbers for all transactions adding new master records to the file. A field check should be performed on numeric fields in each record such as quantity and unit cost. The input records should be checked for correctness in sequence, and any cards out of sequence should be rejected. A reasonableness test might also be performed on the quantity and unit cost on each input record relative to the corresponding values of those items on the inventory master file. Any issue transactions which reduce the balance on hand as recorded in the file to a negative amount should be flagged for review. The list of error transactions containing items which fail to pass one or more of these tests should be reviewed by data control personnel, and each error should be corrected prior to resubmitting the transaction in the next day's run. Similar edit checks might also be included in the purchase order preparation and weekly report generation run.

Use of disk files. If the master files in this system were maintained on magnetic disk storage instead of magnetic tape, the processing of receipts and issues of inventories to update all related files and prepare purchase orders could be accomplished in a single integrated process, rather than in the several separate steps represented by Fig. 13.9. The various reports could be generated when needed, rather than on a periodic basis. Disk files together with terminals would also enable the several master files to be interrogated by purchasing, and perhaps other, departments whenever the need arose. Spooling could be used in those runs which prepare more than one printed report, such as the raw materials inventory update and purchase order preparation runs. Many tape loading and handling steps would be eliminated. Disk file storage could thus generate considerable savings in input and output steps and computer operator time, as well as make the system more useful to the managers and personnel associated with it.

Possible Real-Time Applications

Except for certain unique situations, real-time systems have not generally been applied to the purchasing function. The unique situations are those in which buyers must make quick decisions based upon circumstances which may change rapidly. The stockbroker is one example of a buyer in this situation. Most brokerage houses do utilize a real-time system with display terminals which provide them with current stock quotations.

One possible application of a real-time system to the purchasing operation of the "typical" company as described in this chapter involves the receiving function. Terminals could be made available in the receiving department for use in entering all inventory receipts data into the system. The most useful real-time feature of such a system might be its ability to identify critical items of inventory at the time of their arrival at the plant. A list of critical or out-of-stock inventory items would have to be maintained on disk and checked by the system each time the receipt of an item was entered. If an item were identified as criti-

cal, a message would be printed or displayed on the receiving department terminal requesting that the operator inform the appropriate department manager concerning the item's arrival. Of course, the integration of file processing functions mentioned at the conclusion of the preceding section could also be achieved in a real-time system.

REVIEW QUESTIONS

1. What is logistics management? Give some examples of the various kinds of materials flows involved in logistics management within different kinds of organizations.
2. Describe or illustrate an example of a typical production organization structure. Why is an understanding of the production organization structure necessary to the analysis of logistics information systems?
3. What are three basic decisions for which the purchasing department is responsible? Describe the decision criteria and related information requirements for making these decisions.
4. What are the accounting journal entries which summarize the activities involved in the processing of purchase transactions?
5. Describe the data content and organization of the four primary master files which may be maintained as part of a system for processing purchase transactions. Identify input transactions to these files and output reports generated from these files.
6. What departments in a business organization might be involved in the manual processing of purchase transactions? What documents might be used and what data would each contain? In what department would each document originate, and where and for what purposes would each be distributed?
7. Describe the nature and purpose of (a) the purchase requisition, and (b) the receiving report.
8. What control policies and procedures are involved in manual processing of purchase transactions in a typical business organization?
9. How is organizational independence achieved with respect to the processing of purchase transactions?
10. Describe possible similarities and differences in processing of purchase transactions using a computer, rather than a manual system. Emphasize documents, departments, and reports involved in the process.
11. Explain how and by what department in an organization each of the following reports might be used:

    a) stock status report,
    b) cash flow commitments summary,
    c) overdue deliveries listing, and
    d) vendor performance report.

12. Describe several control policies and procedures which might be used in batch processing of purchase transactions by a business organization using a computer.
13. How is a computer based system for batch processing of purchase transactions simplified if magnetic disks are used to store master files instead of magnetic tapes?
14. What circumstances make it worthwhile to apply a real-time system to the purchasing function? Give an example.
15. Describe the nature and function of a real-time system applied to the receiving function of a typical business organization.

DISCUSSION QUESTIONS

16. The purchasing process described in this chapter related to a single plant or store. What differences would exist in the information system of a multiplant or multistore company in which the purchasing operation is centralized?
17. The computerized system described in this chapter prepared purchase orders as one of its outputs. A simplifying assumption was made that each item of inventory was purchased from only one vendor. Under what circumstances might it be more appropriate to select a vendor at the time of placing the purchase order? How would the design of the computerized system have to be revised to do this?

PROBLEMS AND CASES

18. What internal controls relating to a purchasing procedure would provide the best protection against the following situations?
    a) A purchasing agent ordering unnecessary goods from a company of which he is one of the officers.
    b) A vendor overcharging for goods purchased.
    c) An error in the vendor's favor in calculating the total on an invoice.
    d) Theft of inventory by stores personnel, who claim to have never received the goods from the receiving department.
    e) A vendor invoicing the company for a greater quantity of goods than were received.
    f) A vendor delivering unordered goods and sending an invoice requesting payment for them.
    g) A vendor sent two copies of his invoice. The copies became separated and eventually two checks in payment of the two copies of the same invoice were prepared and mailed.
19. The Witt Company is engaged in manufacturing. Certain features of its operating methods are described on the following page.

You are to consider the procedure for the activities described and point out the existing deficiencies, if any, in internal control. Include an explanation of the errors or manipulations which might occur in view of each weakness and your recommendations as to what changes in procedures could be made to correct the weakness.

When materials are ordered, a duplicate of the purchase order is sent to the receiving department. When the materials are received, the receiving clerk records the receipt on the copy of the order, which is then sent to the accounting department to support the entry to accounts payable and material purchases. The materials are then taken to stores where the quantity is entered on bin records.[2]

20. Shown on the following page is a document flowchart of purchasing and cash disbursement procedures for EBM, Inc. As a systems analyst, point out the weaknesses in the procedures, and describe inefficiencies or manipulations which could occur as a result of these weaknesses.

21. You are to design an integrated system for processing purchase transactions using magnetic disk file storage. The system maintains an inventory master file, an open purchase order master file, and a vendor history file, all on the disk. System inputs are receipts and issues of inventory keyed in as they occur from receiving or stores. System outputs are batches of purchase orders, each in four copies, and periodically generated reports of cash flow commitments, overdue deliveries, and vendor performance.

    The system outputs are generated by programs which are separate from the main update program. The main program begins by updating the inventory master file. If the balance of the item falls below its reorder point, the item is written onto a reorder file on a separate disk. This file is processed at the end of each day to prepare the purchase orders.

    The main program then updates the open purchase order file for inventory receipts. If a receipt completes the purchase order, the purchase order is deleted from the file, and vendor performance data obtained from the completed purchase order is then processed to update the appropriate vendor history record.

    The purchase order preparation program operates on the reorder list after that list has been sequenced by vendor code number. This program accesses the vendor history file to obtain the name and address associated with each vendor number from the reorder file. It then generates the completed production order, adds it to the open purchase order file, and writes the purchase order.

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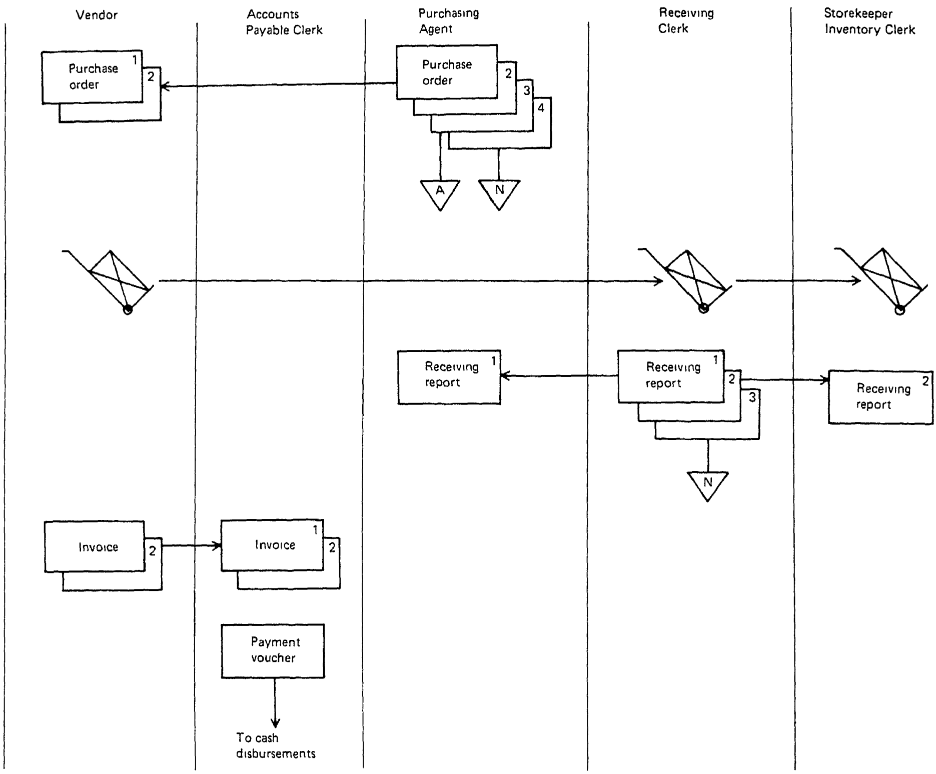
[2] Adapted from Question 8, Auditing Section, American Institute of Certified Public Accountants Examination, May 1951. Copyright © 1951 by American Institute of Certified Public Accountants and reprinted with permission.



Required:

a) Prepare a systems flowchart of this system.
b) Prepare a macroflowchart of the main update program.
c) Prepare a macroflowchart of the purchase order preparation program.

22. What internal controls in a computerized inventory update program shoul provide the best control over the following situations?
    a) Posting of an inventory receipt to the wrong file record due to an incorrect item number.
    b) Failure to process several inventory transactions because the cards were lost while being brought to the computer center from the keypunch room.
    c) Processing of an issue transaction in which the quantity issued was erroneous, with the result that the on-hand balance in the inventory record fell below zero.
    d) Erasure of the only copy of the inventory master tape due to inadvertent use of the tape as an output file in another program.

e) Posting of an inventory receipt on which the item cost was erroneously keypunched as \$20.00; the correct unit cost was \$2.00.
f) Due to several miscellaneous errors occurring over a period of several years, a large discrepancy arose between the quantity on hand of an important subassembly and the balance on hand according to the inventory master.

23. Culp Electronics Company processes inventory receipts as they arrive at the receiving dock by means of online data terminals located in the Receiving Department. All of the six Receiving Department employees have been taught to operate the terminals. Each inventory receipt entered into the system is processed to update the appropriate records in both (1) an inventory master file and (2) a file of open purchase orders.

    Required:

    a) What items of data should be entered into the system each time an operator uses the terminal to report the receipt of a shipment?
    b) Describe several means by which the system could be programmed to check the accuracy and validity of the input data entered from the Receiving Department. Relate your answer specifically to the data items mentioned in part (a).

24. The Doyle Company processes its inventory transactions by computer. Data on inventory receipts, issues, and other file changes are keyed directly from source documents onto magnetic tape using key-to-tape encoders. The transaction tape is then sorted and processed to update an inventory file maintained on a magnetic disk unit. Outputs of this process include a list of items to be reordered on magnetic tape, a printed stock status report, and a summary printout listing error transactions and run totals.

    Required:

    a) Prepare a systems flowchart of all operations described above.
    b) Describe a comprehensive set of control policies and procedures for this computerized inventory processing system. Describe the nature and purpose of each policy or procedure. Be sure to relate each policy or procedure specifically to the data and operations of the system as described above.

25. The accounting and internal control procedures relating to purchases of materials by the Branden Company, a medium-sized concern manufacturing special machinery to order, have been described by your junior accountant in the following terms:

    After approval by manufacturing department foremen, materials purchase requisitions are forwarded to the purchasing departmant supervisor who distributes such requisitions to the several employees under his control.

The latter employees prepare prenumbered purchase orders in triplicate, account for all numbers, and send the original purchase order to the vendor. One copy of the purchase order is sent to the receiving department where it is used as a receiving report. The other copy is filed in the purchasing department.

When the materials are received, they are moved directly to the storeroom and issued to the foremen on informal requests. The receiving department sends a receiving report (with its copy of the purchase order attached) to the purchasing department and forwards copies of the receiving report to the storeroom and to the accounting department.

Vendors' invoices for material purchases, received in duplicate in the mailroom, are sent to the purchasing department and directed to the employee who placed the related order. The employee then compares the invoice with the copy of the purchase order on file in the purchasing department for price and terms and compares the invoice quantity received as reported by the shipping and receiving department on its copy of the purchase order. The purchasing department employees also check discounts, footings, and extensions after which they initial the invoice to indicate approval for payment. The invoice is then submitted to the voucher section of the accounting department where it is coded for account distribution, assigned a voucher number, entered in the voucher register, and filed according to payment due date.

Required:

Discuss the weaknesses, if any, in the internal control of Branden's purchasing and subsequent procedures. Suggest supplementary or revised procedures for remedying each weakness with regard to (a) requisition of materials and (b) receipt and storage of materials.[3]

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[3]Adapted from Question 4, Auditing Section, American Institute of Certified Public Accountants Examination, May 1963. Copyright © 1963 by American Institute of Certified Public Accountants and reprinted with permission.

Chapter 14

Accounting Information Systems for Logistics Management II

Chapter 13 discusses information systems serving the purchasing function. In a retail or wholesale organization, purchasing represents the primary factor in logistics management. However, in a manufacturing organization, the purchasing function is only the beginning of the materials flow process. The second major step in this process is the production operation. The nature of the production management function, and of the information systems which serve it, comprises the subject of this chapter.

THE PRODUCTION MANAGEMENT FUNCTION

Referring to the organization chart in Fig. 13.1 we observe that the production management function is primarily the responsibility of the production planning department, the plant manager, the general foreman, and the various production department foremen. Generally the production planning department is responsible for planning and scheduling of production, while the plant manager, general foreman, and departmental foremen are responsible for the coordination and control of production operations. Important service functions to these activities are performed by the engineering, maintenance, and stores departments.

Production Planning

The production planning function involves determining what should be produced and when it should be produced. Closely related to production planning is the engineering function of determining how a given product should be produced.

Deciding what should be produced consists basically of establishing the appropriate quantities of each product to be manufactured during a given time period. The decision process encompasses the specification of a suitable mix of styles, sizes, colors and other features. For those firms which manufacture

goods to customer orders, this aspect of production planning may be quite simple. However, those firms which manufacture goods for inventory must utilize information on current inventory levels and forecasted sales by product for making these decisions.

The engineering function involves establishing, for each product or subassembly which the firm manufactures, the standard quantity of each raw material or part required for the product, the precise labor operations required for each product, the standard amount of time each operation should consume, and the work station or machine at which each operation should be performed. These specifications are developed for a product at the time when it is first introduced into the firm's product line, and may be revised periodically thereafter. Materials specifications for a product are embodied in a document called a *bill of materials,* illustrated in Fig. 14.1. Labor operations, with their corresponding machine requirements and standard time requirements, are indicated on a document called an *operations list* or *routing sheet,* illustrated in Fig. 14.2. Copies of both of these documents are prepared and kept current by the engineering department for every item produced, and are used extensively in production planning and control. In a firm which uses a standard cost system, the standard materials cost per unit and standard labor rate per operation might also be included on the bill of materials and operations list, respectively.

Planning the specific time at which product items will be manufactured is referred to as production scheduling. The scheduler must know what quantities of each product are to be produced, what resource requirements exist for each product, and what resources are available. Determination of the quantities to be produced is the stage in production planning which precedes scheduling. Resource requirements are then established by multiplying the quantity of each product to be produced by the standard per unit requirements specified in the bill of materials and operations list for the product. Three types of resources, materials, labor, and equipment, must be brought together at the same point in time for production to occur. The availability of these resources is made known to the scheduler by materials stock status reports, personnel reports, and machine availability and capacity reports. The scheduler must coordinate the work of all production employees and the use of all available machines and materials throughout the plant to achieve maximum production at a minimum expenditure of time and resources. His output is a production schedule for each factory production department, which indicates what jobs must be performed within that department during the period covered by the schedule.

Finally, the production scheduler must know the relative priorities of the various items in the process of production. Some items will have high priority because they are out of stock, backordered, rush ordered, or behind schedule for a promised delivery date. Such high priority items must be given preference over lower priority items in production scheduling and operations.

BILL OF MATERIALS				
Assembly No. 2742816	Assembly Name Miniature Calculator	Page 1 of 2	Approved by FDK	Date 1-9-74

Part Number	Description	Quantity per Assy
7054396	Calculator Unit	1
4069136	Lower Casing	1
1954207	Screw	8
3049218	Battery	1
4069245	Upper Casing	1
1954209	Screw	6

Fig. 14.1 Bill of Materials.

OPERATIONS LIST					
Stock number		Description	Date prepared	By	
Dept no	Oper no	Operation description	Machine requirements	Stand hours	Set-up hours

Fig. 14.2 Operations list.

Operations Control

The operations control function includes all activities related to expediting, coordinating, and controlling the operations of the various production departments. At least three basic standards – time standards, cost standards, and quality standards – must be met in this function. Time standards are embodied

in the operations lists, which, in turn, are embodied in the production schedule. The control function with respect to time standards is carried out by production department foremen, who must coordinate the operations of the men and equipment under their direction to complete the scheduled production. The performance of the foremen is evaluated by the general foreman and plant manager on the basis of comparison of scheduled unit production with actual unit production. The foremen must also observe the priorities attached to various production jobs; their success in this regard is also an important element of performance.

The control function with respect to cost standards is also carried out by production department foremen; the results can be evaluated by the plant manager and general foreman on the basis of reports generated by the cost accounting department. The decisions of the departmental foremen regarding the assignment of workers to jobs are made in accordance with the experience, efficiency, and quality of each employee's work. The quality of those decisions, and the quality of each foreman's supervision, are reflected in materials usage costs and labor costs. Other decisions of the departmental foremen are reflected in overhead costs such as repairs and maintenance, supplies, small tools, power, and so forth. A good cost accounting system uses the standard material and labor requirements developed by the engineering department to provide a standard cost per unit for all production work performed. Cost accounting reports such as the one illustrated in Fig. 14.3 compare actual costs within each department to standard costs, and thus provide important feedback to departmental foremen on their performance. Similar reports are provided to the plant manager and the general foreman for use in evaluating their own performance and that of the foremen under their supervision.

The quality control function may be performed by the engineering department and/or by a separate inspection or quality control department. The function involves testing or inspecting completed items of production for defects in materials or workmanship. It is often performed on a sample basis, in which case the entire lot of completed items is not inspected unless a certain portion of the sample is found to be defective. All defective units are returned to the appropriate factory department for reworking. Costs of reworking should generally be charged to the foreman in whose department the defective work occurred. The information needed to perform this function is provided by the engineering department. However, quality results as determined by this function are reflected in production costs related to reworking, and are thus relevant to performance evaluations of department foremen and the general foreman.

One other important production control function is the *expediting* or *dispatching* function. This function involves monitoring the progress of production, particularly of high priority items. The expediter must have knowledge of the current status of all work in process. He is frequently called upon to report such information in response to a customer request. The expediter is responsible for maintaining a smooth flow of production through the factory,

DAILY LABOR COST EFFICIENCY REPORT										
Dept no. 473 Machining			Foreman Oscar Nagursky				Date Feb 28, 1974			
Employee		Order No	Operation		Stand Rate	Hours		% Efficiency	Total Cost	
No	Name		No	Description		Actual	Stand		Actual	Stand.
4099	Jones, Harold	1406	352	Drill	3 00	3 6	3 5	97	10 80	10 50
4099	Jones, Harold	1406	382	Burr	3 00	4 4	4 0	91	13 20	12 00
4166	Bond, Jim	1381	425	Grind	2 90	3 0	3 6	120	8 70	10 44
4166	Bond, Jim	1406	392	Bore	2 90	5 0	5 5	110	14 50	15 95
	Dept Totals					128 0	125 4	98	362 20	356 20

Fig. 14.3 Labor cost efficiency report for a production department.

and may authorize deviations from the production schedule if necessary to accomplish this goal. He must also report significant deviations from scheduled production to the plant manager, the general foreman, and the production planning department.

THE PRODUCTION INFORMATION SYSTEM

In most manufacturing organizations, there are two primary information subsystems for production management. One concerns the physical operations and elements of production, while the second concerns the cost elements of production. In automated systems, these two subsystems tend to become integrated, and so this chapter covers both subsystems. This section reviews the accounting transactions arising from production operations, describes and illustrates the primary master files maintained in production information systems, and then discusses examples of manual, computerized batch processing, and real-time information systems for production management.

The Accounting Transactions

All of the accounting transactions pertaining to production operations within a company are internal transactions, which means that there is no outside party to these transactions. Two basic accounting journal entries summarize the activities of the production process. The first of these is as follows:

Work-in-Process Inventory	XXX	
Raw Materials Inventory		XXX
Payroll		XXX
Manufacturing Overhead		XXX

This is a composite entry representing the charging of the three major categories of production cost to production in process. The raw materials inventory portion of the entry is generally made at the beginning of production of a batch of units, when materials are issued for production from the storeroom. The payroll portion of the entry is made every week or every other week, depending upon how frequently production employees are paid. The overhead portion of the entry represents overhead applied to work in process rather than actual overhead incurred. It is necessary to make this distinction because manufacturing overhead costs, unlike materials and labor, cannot be traced directly to units of work in process. Therefore, overhead is generally applied at a standard rate, using direct labor hours or direct labor costs as a base.

The actual overhead costs are recorded by the accounting department as they are incurred. Numerous factory overhead accounts, including supplies, indirect labor, small tools, overtime premium, power and other utilities, insurance, taxes, maintenance, and depreciation, are debited for these costs. These detailed overhead accounts are coded both by type of cost and by the department for which the cost is incurred. Credits are made to accounts payable, payroll (for indirect labor, overtime premium, etc.), and other accounts (accumulated depreciation, accrued taxes, etc.). At the end of each reporting period (generally monthly), all balances in these detailed overhead accounts are closed to the manufacturing overhead control account. The net balance remaining in the manufacturing overhead control account after the closing represents over- or underapplied overhead. In a standard cost system, this difference is broken down into standard overhead cost variances. The net difference is eventually written off to cost of goods sold.[1]

The second basic accounting journal entry relating to the production process is as follows:

Finished Goods Inventory	XXX	
Work-in-Process Inventory		XXX

This entry reflects the completion of production goods and their transfer from the final assembly department into the finished goods storeroom, or to the shipping department for shipment to warehouses or customers.

The Master Files

Two master files which are an integral part of production processing and reporting operations are the open production order file and the work-in-process master file. Two other working files used in the process are the file of operations lists and the bill of materials file. Two master files affected by production processing which are described in earlier chapters are the raw materials inventory master file and the finished goods inventory master file.

[1]For a more extensive discussion of accounting for overhead costs, see Charles T. Horngren, *Cost Accounting: A Managerial Emphasis,* Third Edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972), Chapters 4 and 9.

MILL WORK TICKET

M.O. ITEM	CUSTOMER	SHIP-TO NO.	CUSTOMER NO.	CUSTOMER ORDER NO.	DATE PROM.	QUAL.	SPEC NO.	PROC NO.
123456 00	FISH STEEL	1240	1011	12C418-11	4-217	CQ	1420	711

PRODUCT GROUP	ORDERED WEIGHT	INGOT SPEC CODE	HEAT NO.	PRODUCT SIZE-IN. T-W-L
HR F PKL SULF HVY OIL ME COIL	24.000	107 3412	27463	.125 X 56.5 X COIL

OPER NO	FAC NO	OPERATION DESCRIPTION	SIZE T	SIZE W	SIZE L	PROC CODE	DATE SCHD	LIFTS SCHD	WEIGHT SCHED	SPECIAL INSTRUCTIONS	X O	SP NO
05	00	PROVIDE STEEL	4.0	X 54.0	X112.0		203	4	27200			
10	12	HR 1FIN COIL	.125	X 56.5	XCOIL	212	205	4	24800	CONTACT MET B14 ROLLING		
15	22	PKL OIL ME				111	210	4	24300	CUT OUT WELDS		
20	81	PACKAGING				714	214	4	24300	USE CUST SKIDS		
25	91	SHIPPING	.125	X 56.5	XCOIL		217	4	24300	NO DELIV FRI PM		

Fig. 14.4 Production order. (Reprinted by permission from *Primary Metals-Basic Production Planning and Control System*, Vol. I. Copyright © 1971 by International Business Machines Corporation.)

The open production order file contains a record of each production order currently being processed in the factory. This file is maintained by the production planning department, which also initiates the preparation of production orders. In a manual system, the file consists simply of the production order documents for all orders in process. An example of a production order appears in Fig. 14.4. Basically each production order indicates the quantity of product to be manufactured, the operations necessary to produce it, and the scheduled starting date of each operation. In an automated system, the version of the file stored on a machine readable medium would contain basically the same data shown on the document. The production order number would serve as the control field, and each operation would represent a subrecord of the corresponding production order record.

Primary inputs to the open production order master file are newly initiated production orders and records of operations completed for outstanding orders. Production orders are initiated once the production planning department decides what quantities of what products to manufacture during the forthcoming period. The operations list for a product is obviously a basic reference document in preparing a production order for that product. As work on a production order proceeds, records of operations completed are prepared in the factory and processed to update the record of operations to be performed on each production order. The open production order file serves as an important reference regarding the status of orders in process. It is also the primary source of information for purposes of preparing production schedules for all producing departments in a factory.

The data content and organization of the work-in-process inventory master file depends upon the type of costing system used by the organization. The two basic types of cost systems which may be used are *job order costing* and *process costing*. In job order costing, manufacturing costs are accumulated according to production jobs in process, and so the work-in-process master will include one record for each production order in process. In process costing, manufacturing costs are accumulated by departments, and the work in process master includes a summary cost record for each production department. Firms which produce goods to specific customer orders generally utilize job order costing, whereas firms which produce goods for inventory may use either job order or process costing. The systems described and illustrated in this chapter are based on the model of a firm which produces goods for inventory and uses a job order costing system.[2]

In a manual system, the work-in-process master may consist simply of a cost summary sheet for each order in process upon which the costs for the order are accumulated. An example is shown in Fig. 14.5. The cost accounting department maintains the data on these records on the basis of source documents evidencing material and labor usage in production. As explained earlier, overhead costs charged to work in process represent applied rather than actual costs. The data maintained on work-in-process master records in an automated system would be virtually the same as that shown on the summary cost sheet. Production order number would serve as the control field for the file, and each record would contain three separate sets of subrecords – one each for detailed materials, labor, and overhead cost records. Once a production order is completed, the cost data on this record are summarized to determine total and per unit cost for the order.

In some automated production information systems which possess a high level of integration, the open production order master and work-in-process master might be combined in one integrated master file of operations and cost data. This facilitates the processes involved in maintaining the currency of the file and generating control reports.

The data content and organization of operations lists and bill of materials records have already been illustrated. Files containing these records utilize product stock number as the control field, and are an essential reference for production planning. The raw materials inventory file, discussed in Chapter 13, is an important source of information for production planning and control, and is updated as materials are issued into production, as illustrated previously in Fig. 13.9. The finished goods inventory master file, discussed in Chapter 12, is updated as production orders are completed.

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[2]For a more extensive coverage and comparison of job order and process costing, see Charles T. Horngren, *op. cit.*, Chapters 4 and 17.

PRODUCTION ORDER COST SUMMARY

Order no	Item no	Item description

Quantity started	Date started	Quantity completed	Date completed

Direct materials costs

Date	Dept no	Req no	Description	Total cost

Direct labor costs

Date	Dept no	Oper no	Description	Total hrs	Total cost

Applied manufacturing overhead costs

Date	Dept no	Basis of application	Total cost

Fig. 14.5 Work-in-process cost summary sheet

A Manual System

A document flowchart of a manual system for processing data relating to production operations appears in Fig. 14.6. Once again it must be emphasized that this and all subsequent illustrations are examples, rather than descriptions, of a real system. The production area is one in which the differences between firms are often quite significant. However, for most manufacturing firms the general pattern of information flows is likely to be somewhat similar to that shown.

The illustration shows that production data processing begins in the production planning department. This department reviews current sales forecasts from the marketing department, finished goods stock status reports from the finished goods department, and raw materials stock status reports from the inventory clerk. On the basis of these inputs, the department decides the types and quantities of products which will be produced during the next period. The operations list is then used as a basis for generating production orders, and the

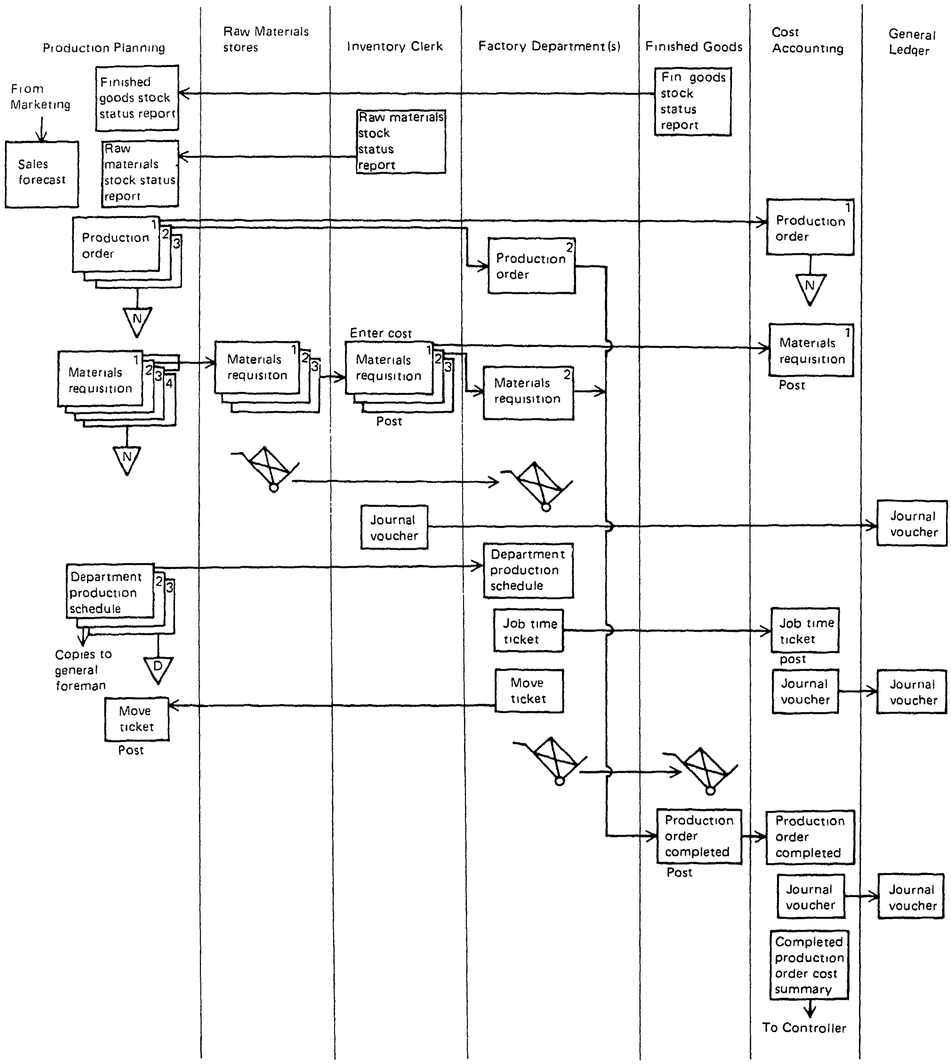


Fig. 14.6 Document flow in a manual system for processing of production data.

materials specifications list is used to prepare materials requisitions for each production order.

One copy of each production order is sent to the cost accounting department, where it is used to establish a work-in-process record for the job. A second copy is sent to the production department in which the work is to begin. This copy will accompany the work in process on its way through the factory.

MATERIALS REQUISITION No 14160

Date	Department Issued to	Production order no

Item No	Item description	Quantity	Cost/unit	Total cost

Received by ______________ Date __________

Fig. 14.7 Materials requisition.

A third copy is retained by production planning and filed in the open production order file.

The production planning department also prepares several copies of a materials requisition, which authorizes the transfer of raw materials from the stores department to the appropriate factory department. An example of a materials requisition is illustrated in Fig. 14.7. The items and quantities listed on the materials requisition are determined according to the specifications provided on the bill of materials. For each production order, one or more materials requisitions may be issued by production planning – one for each department to which materials are issued according to the bill of materials. In some cases all materials may be issued to one department, whereas in other cases various portions of the materials may be issued to several different production departments as the work proceeds through the factory.

One copy of each materials requisition is filed by requisition number in the production planning department. Three other copies of each are sent to the raw materials storeroom, where they provide authorization to the stores foreman to release the goods to the factory. When this transfer occurs, the person receiving the materials signs the form and has the cost per unit data entered by the inventory clerk, who retains one copy and transmits another copy to cost accounting for entry to the work-in-process master. The recipient of the goods retains the third copy to be attached to the factory copy of the production order. The inventory clerk posts each requisition to the issues and on-hand fields of the raw materials inventory master and, after each batch is posted, prepares a journal voucher of the debit to work in process and credit to raw materials inventory which is sent to the general ledger clerk.

The production planning department also prepares daily production schedules for all factory production departments. The basis for preparing these schedules is the open production order file, which is kept current to reflect all

operations remaining to be performed on all outstanding production orders. The production schedule for each department lists all operations to be performed in the department each day, including the production order number, the machine number, quantity, total time required, start and stop time, priority of the order, the location from which the work in process is to arrive, and the location to which it must be sent when completed. Each departmental production schedule must, of course, properly reflect the availability of machine time and labor in the department. A copy of each department's production schedule is sent at the beginning of each day to the department foreman. Another copy of each is sent to the general foreman, while a third copy is filed by date in the production planning department.

In the individual factory departments the production schedule provides a guide to the foreman in assigning workers to jobs. Departures from the schedule may be necessary in the event of machine breakdowns, employee absenteeism, unavailability of materials, the need to rework some materials, and so forth. Foremen must observe the priority status of each job to the maximum extent possible if it becomes necessary to depart from the schedule. As each factory employee completes the operation to which he is assigned, a job time ticket (see Fig. 14.8) is prepared detailing the work performed. All job time tickets are approved and signed by the department foreman and sent to the cost accounting department for posting to the work-in-process cost summary sheets.

The transfer of work in process from one work station or department to another as operations are completed is recorded on a document called a move ticket. Move tickets are provided to production planning as a source for updating the production order file. The final move ticket, signed by an employee in finished goods, records the transfer of the product to the finished goods storeroom. When this copy of the move ticket is received by production planning, the corresponding production order may be removed from the open production order file.

The cost accounting department is responsible for maintaining the file of work-in-process cost records. New records are added to this file upon receipt of new production orders initiated by production planning. Materials costs are posted to this file from copies of materials requisitions. Direct labor costs are posted from job time tickets. Overhead costs are often applied on the basis of direct labor hours or direct labor costs, and therefore are posted at the same time as labor costs. The cost accounting department initiates a journal voucher reflecting each batch of job time tickets posted which contains a debit to work in process and credits to payroll and manufacturing overhead. This journal voucher is transmitted to the general ledger clerk, and posted to the general ledger.

When the finished products are transmitted to the finished goods storeroom from the factory, the production order and attached materials requisitions accompany them. This completed production order is used by finished goods personnel to post to the finished goods inventory file. The copy is then trans-

JOB TIME TICKET			
Date	Dept no	Department name	
Prod ord	Oper no	Operation description	
Employee no	Name	Hourly rate	
Start time	Stop time	Total hours	Quantity completed
Approved by ______________ Department foreman			

Fig. 14.8 Job time ticket.

mitted to cost accounting, where it provides the basis for closing the work-in-process record of the job. After each batch of these is processed, a journal voucher is prepared by the cost accounting department indicating the debit to finished goods inventory and credit to work in process. The voucher is transmitted to the general ledger clerk for posting to the general ledger. The cost accounting department also prepares for the controller a completed production order cost summary, which contains an outline of all materials, labor, and overhead costs accumulated for the job.

The cost accounting department is responsible for the periodic preparation of departmental cost performance reports for the various production departments. Actual materials usage and labor costs for this purpose are accumulated from materials requisitions and job time tickets. Actual overhead costs are obtained from a summary analysis of the factory overhead ledger provided by the accounting clerk responsible for maintaining that ledger. This analysis indicates the total of each type of overhead cost incurred by each factory department. The cost accounting department maintains current standard costs for materials usage, labor, and overhead, and these standard costs are also used in preparing performance reports. As indicated in the report illustrated previously in Fig. 14.3, each departmental cost performance report is a summary and comparison of actual and standard costs for the most recent period, with cumulative totals encompassing several recent periods perhaps also provided. Copies of each of these reports are sent to the appropriate departmental foremen, and duplicate copies of all reports may be provided to the general foreman, the plant manager, the controller, and other executives.

Organizational independence with respect to production processing operations is achieved by separation of the recording functions (including the production planning department, the inventory clerk, the cost accounting department, and the general ledger clerk) from the operating and custodial functions of the various factory departments and the raw materials and finished goods store-

rooms. This separation of duties provides assurance that all movements of materials in the firm are properly and accurately recorded.

The most significant control problems in the production area are prevention of loss of inventories and the maintenance of efficient production operations. Controls over loss of inventories, in addition to separation of duties, include effective supervision by factory foremen and stores foremen, limitations on access to the storerooms containing raw materials and finished goods, and physical security measures such as the placing of plant protection personnel at factory gates. Also important are the documentary controls on all transfers of materials within the factory. In the case of all such transfers, the recipient of the materials must sign a document acknowledging the receipt and verifying the accuracy of the amount recorded on the document. The document, which may be a materials requisition or a move ticket, is then immediately routed to a recording center, such as cost accounting or production planning. If materials shortages do occur, this system enables tracing the responsibility for the shortages to a specific department.

Control of production efficiency is provided by comparisons of actual production with scheduled production and by departmental cost performance reports. Comparisons of actual and scheduled production by the departmental foremen, general foreman, and production planning department establish a basis for daily control of operations. The expediting function, which closely monitors the progress of high priority items through production, and brings any delays to the attention of the appropriate managers, also contributes to the day-by-day control of production efficiency. Departmental cost performance reports measure production efficiency in financial terms, on a daily, weekly, or monthly basis. In the long run, departmental cost performance reports contribute to control of production efficiency by encouraging foremen and managers to improve their decisions, policies, and procedures.

One other aspect of production control which is not reflected in the flowchart is quality control. The quality inspector's station is often the last factory department through which a product passes before reaching the finished goods storeroom. If the product passes inspection, the inspector's report is attached to the move ticket which acknowledges receipt of the goods in the finished goods storeroom. These documents are routed to production planning. Any items which do not pass inspection are sent back to the appropriate factory department, and an inspector's report indicating the rejection is routed to production planning. The latter department must then include the necessary rework operations in preparation of subsequent production schedules. Periodically prepared summaries of work failing to pass inspection may be used by production management to pinpoint quality control problems within the factory.

The flowchart also does not indicate the special procedures which are necessary in the event that actual materials usage is greater than or less than the amount requisitioned. If the foreman determines that a larger quantity of

materials is needed, he must inform the production planning department of the items and quantities required. The production planning department issues another materials requisition, which undergoes processing identical to the original version. To provide control over materials issued in this manner, the authority to initiate requests for additional materials must be restricted to foremen only, since foremen will eventually be held accountable for the excess materials costs.

If a quantity of raw materials is left over after production within a department is completed, the departmental foreman must prepare two copies of a returned materials report. These copies are taken, together with the materials themselves, to the raw materials storeroom. There the custodian signs one copy acknowledging receipt of the exact items and quantities indicated on the report, and this copy is sent to cost accounting for posting to the work-in-process master file. The other copy is provided to the inventory clerk for posting to the raw materials inventory file.

A Computer Based Batch Processing System

A document flowchart of the production information system of a typical manufacturing company using computerized batch processing appears in Fig. 14.9. As in previous descriptions of batch processing systems, it is assumed that master files are maintained on magnetic tape storage, and that punched cards are used for data input.

A comparison of Fig. 14.9 with its manual counterpart, Fig. 14.6, reveals that the computer has replaced the inventory clerk and has assumed many of the clerical functions performed within the production planning and cost accounting departments. The production planning department decides what is to be produced on the basis of the same information — sales forecasts and inventory status reports — but this information is prepared by computer instead of by various other departments. Production planning prepares a set of manufacturing authorizations indicating the quantity of each product to be produced and the relative priorities of each product. This is provided to the input preparation department and becomes input to a computerized process which prepares production orders, materials requisitions, and production schedules. The open production order file, maintained by the production planning department in the manual system, and the work-in-process master file, maintained by the cost accounting department in the manual system, are instead maintained together as a single integrated file by computer.

The functions performed by raw materials stores, the various factory departments, the finished goods department, and the general ledger clerk are quite similar in the two systems. The factory departments must route the job time tickets and move tickets to input preparation instead of to cost accounting and production planning. Factory foremen must still manually prepare requisitions for excess materials needed or reports for unnecessary materials returned in the event that actual usage varies from the amount originally requisitioned. The finished goods department is no longer responsible for maintaining the

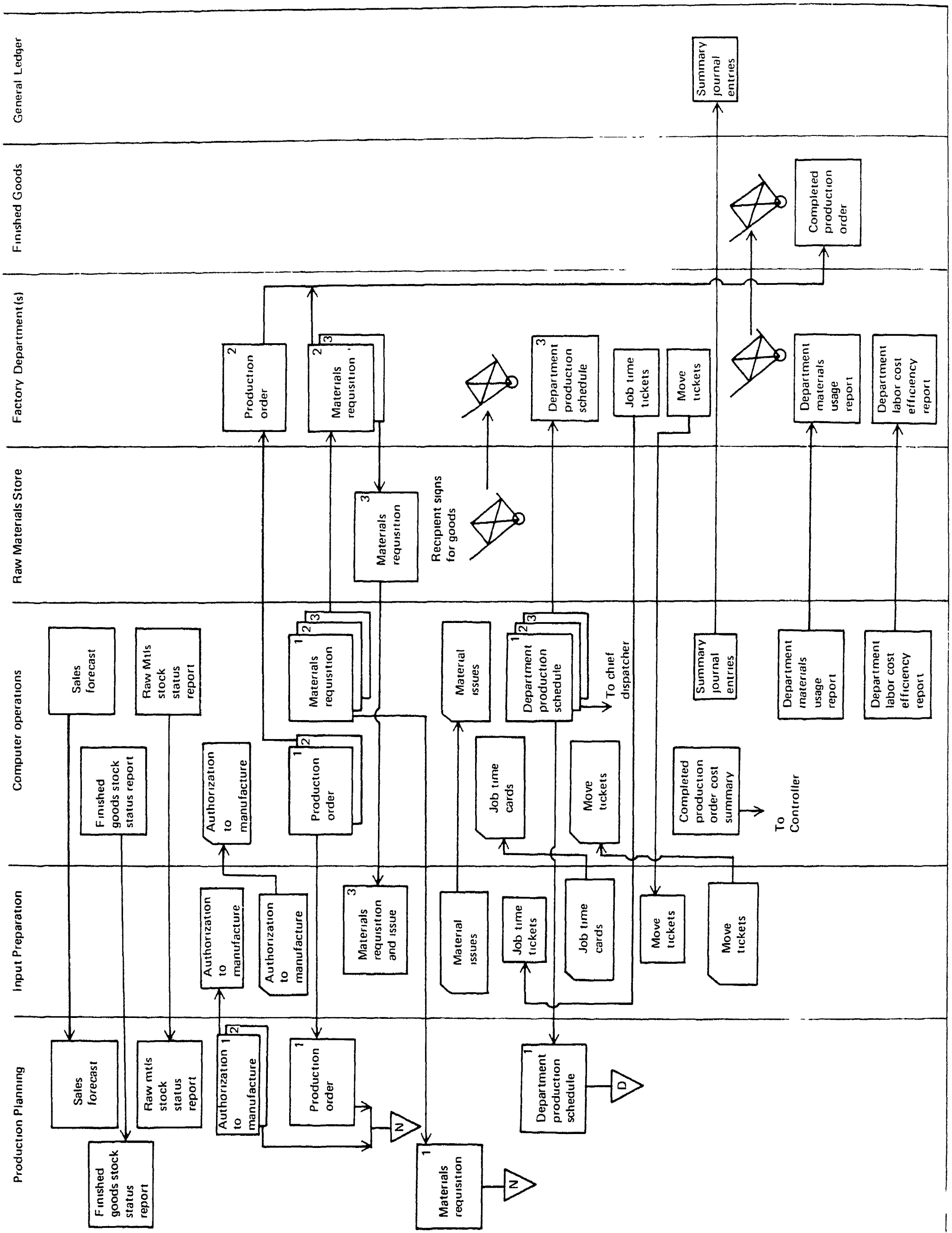


Fig. 14.9 Document flow in computerized batch processing of production data.

finished goods master file, which is instead maintained by computer. The general ledger clerk receives journal vouchers as computer printouts rather than as manually prepared documents. Actually, the general ledger function itself could easily be computerized, and a system incorporating this feature is described in Chapter 16.

Figures 14.10, 14.11, and 14.13 illustrate by means of systems flowcharts the computer operations involved in (1) production order and materials requisition preparation, (2) production scheduling, and (3) cost accounting. This section discusses each of these three areas of computer operations in turn, considers control policies and procedures directly applicable to these operations, and describes the efficiencies which could be achieved in the system by means of using disk units for file storage.

An important feature of the computerized production information systems described and illustrated here is the integration of open production order and work-in-process data. The combined file resulting from the integration of these two files is referred to as the "production order cost and operations data file." The control field for this file is production order number, and the file contains both physical and cost data for all operations and materials connected with the order. In addition, it is assumed that standard cost data is recorded on this file. In each of the three areas of computer operations covered in this section, the production order cost and operations data file is the key data base in updating and reporting processes.

Preparation of production planning documents. The input preparation and computer processing operations necessary to prepare production orders and materials requisitions are illustrated in Fig. 14.10. These operations are initiated once each week by receipt of "authorization to manufacture" documents or lists from the production planning department. Batch totals prepared from these documents might include a record count and hash totals of product stock number and quantity to be produced. After keypunching and keyverification, the authorizations to manufacture records are sorted into sequence by product stock number, which is the same sequence followed for the bill of materials file and operations list file. The sorting step is performed on a card sorter.

The next step in this process is the processing of the authorization to manufacture cards on the computer together with the operations list file, the bill of materials file, and the production order cost and operations data file. This process is performed sequentially by product stock number. For each product to be manufactured, a production order is compiled from the authorization to manufacture card and corresponding operations list record. A production order number is assigned to this document according to the next highest number available on the production order cost and operations data file. Two or more copies of the production order are printed. For each product, a materials requisition is also compiled from data on the authorization to manufacture card and corresponding bill of materials record. Several copies of the materials requisition are then printed out. All of the materials and operations data, in-

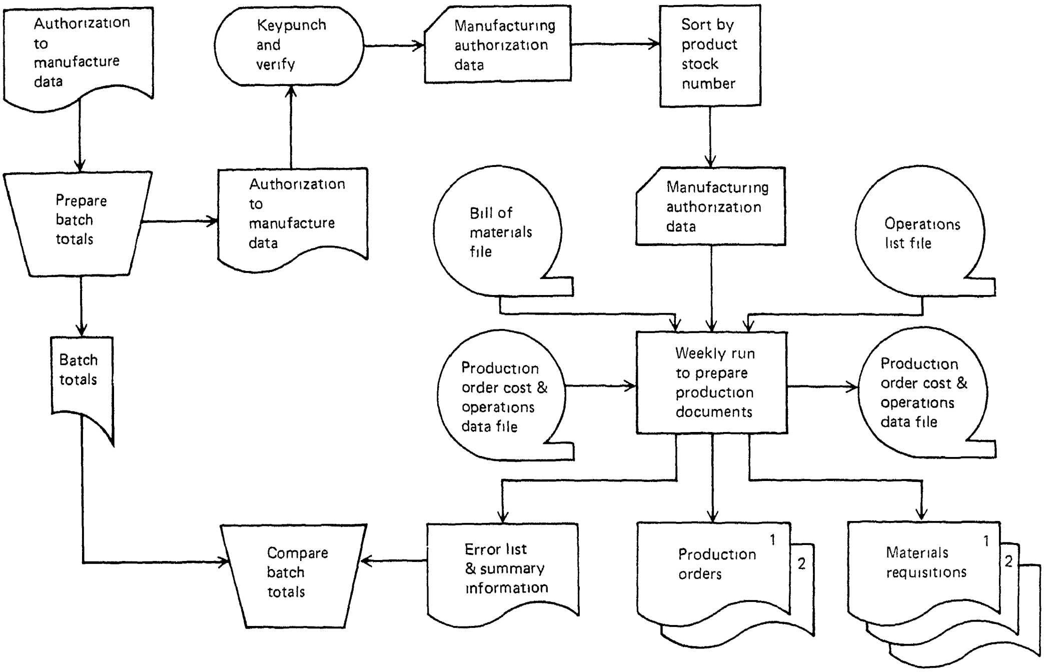


Fig. 14.10 Computerized batch processing system for preparation of production orders and materials requisitions.

cluding standard cost data, from the bill of materials and operations list are written into a new record on the updated version of the production order cost and operations data file. The final output of this computer run is a printed listing of error transactions, batch totals, and other summary information which is compared to the manually generated batch totals as a means of data control.

Production scheduling. This activity is assumed to be performed daily in the computerized system as in the manual system. A systems flowchart of the process appears in Fig. 14.11. The process begins with the updating of the production order cost and operations data file for move tickets evidencing the completion of an operation at one work station and the transfer of the work to the next scheduled work station. Move tickets are received during the shift from the factory and assembled into batches at the completion of the shift. Batch totals taken include a record count as well as hash totals of production order number and quantity of units completed. The batched move tickets are then keypunched and keyverified, after which they are sorted by production order number for processing against the production order cost and operations data file.

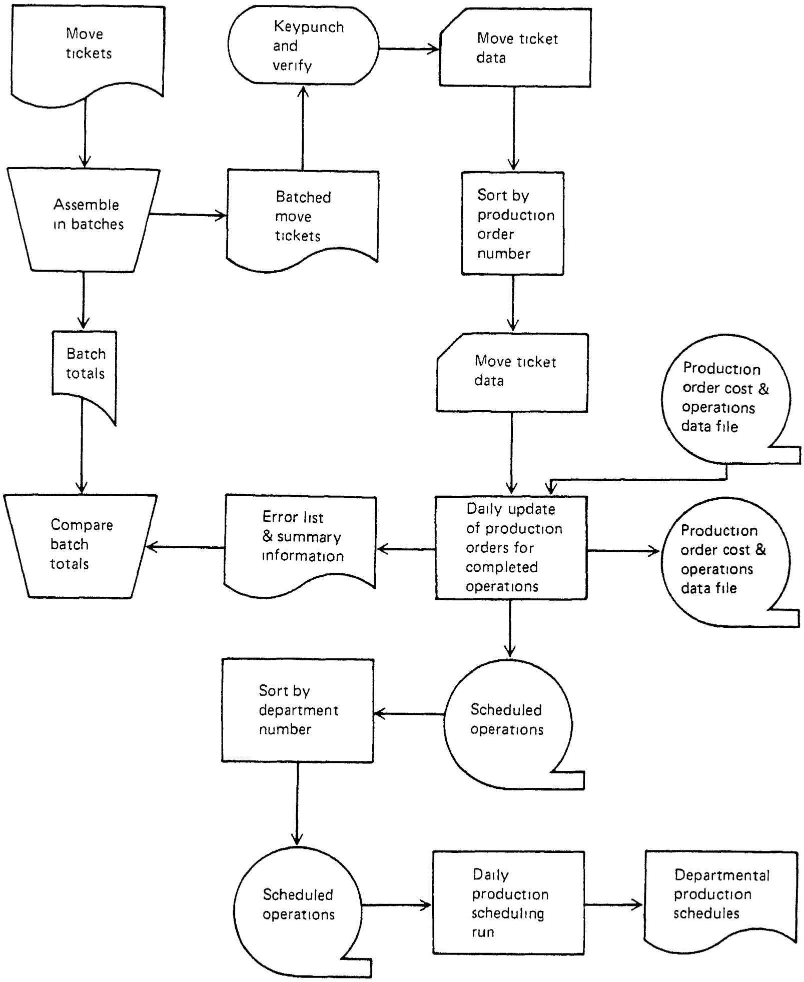


Fig. 14.11 Computerized batch processing system for production scheduling.

The collection and preparation for computer processing of source data on production operations is a common application of source data automation. This observation applies to source data such as that recorded on move tickets and job time tickets. Numerous portable data recorders exist which are designed primarily for collecting production data in machine readable form. Also used are data collection terminals with which factory employees may enter production data by means of setting various switches indicating the operation number, start and stop time, quantity completed, and so forth. Such terminals may be directly online to the computer or connected to an offline tape drive or card punch which records data from all terminals for subsequent batch processing.

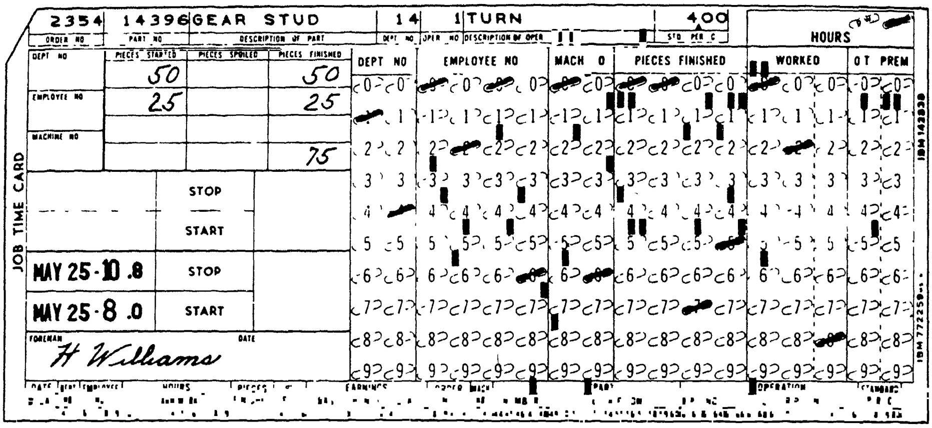


Fig. 14.12 Turnaround document for collection of production data using mark sensing. (Reprinted by permission from *Basic Applications - System /360 Model 20,* Copyright © 1971 by International Business Machines Corporation.)

Also common is the use of turnaround documents upon which production order number, operation number, department number, and related data may be prepunched at the time of preparation of the production orders. As the operations are completed, the employee number, time worked, and quantity completed may be entered on the card in predefined fields for mark sensing. An example of a prepunched card for job time recording upon which production data is recorded for mark sensing upon completion of operations is illustrated in Fig. 14.12.

The processing of move tickets against the production order cost and operations data file updates the record of operations performed on that file, and therefore keeps current the records of operations still remaining to be performed for each production order. Two outputs are generated from this process. One is the familiar printed listing of error transactions and summary information. Batch totals on this printout are compared with those prepared manually prior to processing to check on the reliability of the processed input records. The other output is a tape listing of operations scheduled for performance during the forthcoming shift. Each record on this list includes the production order number, operation number, department number, work station number, quantity to be completed, and standard time requirement for each operation, as well as an indication of the priority of each operation and the appropriate sequence of performance of operations. This tape is then sorted by department number and processed by a special program which prepares departmental production schedules for all production departments. This program contains data on machine and labor capacity of each department. Often programs of this sort may be very sophisticated, having a capability to generate

schedules which represent the optimum assignment of resources for maximum production.

Cost accounting. A systems flowchart of daily computerized operations for cost accounting appears in Fig. 14.13. All of the operations shown are assumed to be performed once daily. To simplify the illustration and accompanying discussion, the chart is divided by means of dashed lines into three separate application areas: materials costing, labor costing, and finished goods file updating.

Materials costing operations utilize the costed material issues tape generated as an output of updating the raw materials inventory file as illustrated in Fig. 13.9. Each record on this tape contains the requisition number, production order number, code number of the department to which the materials were issued, quantity issued, and unit cost from materials requisitions evidencing issues from stores into production. This tape must be sorted into sequence by production order number prior to processing against the production order cost and operations data file. The computer run updates the material usage and cost records in this file. As outputs of the run emerge: (1) a printed list of error transactions and summary information, which includes the summary journal entry debiting work in process and crediting raw materials inventory, and (2) a tape of material usage data, containing actual vs. standard usage and resulting cost variances for all completed operations. The latter tape is sorted by department number and processed to generate daily material usage reports for each production department.

Labor costing operations begin each day with the assembly of job time tickets into batches and computation of batch totals. Among the batch totals prepared might be a record count of the number of job time tickets and hash totals of employee number, pay rate, and hours worked. Job time records are then keypunched, keyverified, and sorted into sequence by production order number on a card sorter for processing against the production order cost and operations data file.

In many firms the generally high volume of job time records, together with the relatively large data content of each record, will justify a more automated form of data preparation than the one illustrated. As described in conjunction with processing of move tickets, several possible techniques of source data automation may be used for this purpose. Recording of job time data on magnetic tape is also a likely possibility. This may be done directly from the source documents by means of key-to-tape encoders, via a conversion of cards to tape using an offline convertor or the computer itself, or through the automatic recording of data entered from factory terminals onto a central tape file. Once recorded on tape, the job time records may be sorted by computer, a process which requires significantly less time than card sorting for high volumes of data.

The next step in this operation is the processing of job time records to post the time of completion of operations and labor rate data to the production order cost and operations data file. If manufacturing overhead is applied on the basis

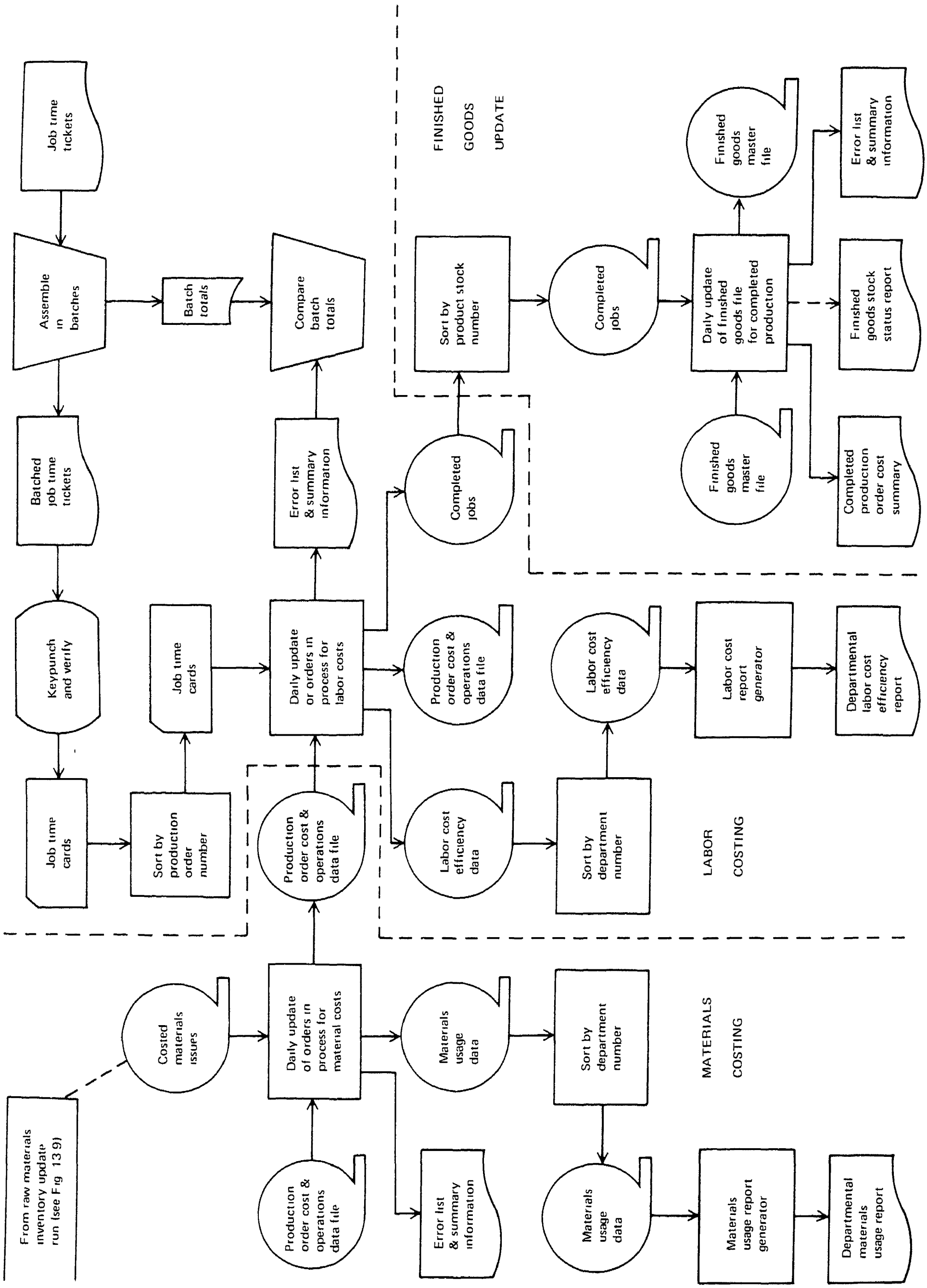


Fig. 14.13 Computerized batch processing system for cost accounting.

of direct labor hours or direct labor cost, this process also calculates applied overhead costs and records these costs in the file. One output of this process is a printed listing of error transactions and summary information which includes the summary journal entry debiting work in process and crediting the payroll and manufacturing overhead control accounts. The report also contains the batch totals accumulated during the run, which are then compared to those compiled prior to keypunching as a data control check.

A second output of this processing run is a tape of labor cost efficiency data. This tape contains the actual and standard time and standard labor rate of all operations performed by all production employees during the day. The tape is sorted by department number and employee code, and is then processed to generate for each production department a daily labor cost efficiency report similar to the one illustrated previously in Fig. 14.3.

The other output of this process is a tape listing of all cost data for production orders which are completely finished as a result of the operations represented by the job time cards. All records of such orders can be eliminated from the production order cost and operations data file, since they no longer represent work-in-process inventory, nor do they require any further production scheduling. The completed jobs tape is sorted by finished goods inventory stock number and is processed to update the finished goods inventory master for the completed stock. The printed listing of error transactions and summary information generated from this run contains, among other things, the summary journal entry debiting finished goods and crediting work in process for the cost of manufacturing the items. The second printed report generated by this run is a series of completed production cost summaries for each product completed. Each of the summary reports on this printout details all production costs for the particular production order, and might follow a format similar to the cost summary sheet illustrated previously in Fig. 14.5.

The third and final report printed out by this run is a finished goods stock status report. As indicated by the dashed line in the illustration, this report is assumed to be prepared once each week rather than once a day, though the latter frequency could certainly be adhered to if considered beneficial. Since the report represents the third printed output of this run, some special provision may have to be made if the organization does not have three printers. One possibility is to write the finished goods stock status report on tape for subsequent printing. Another possibility is to store all data for the relatively small error list and summary report inside the computer until the completion of processing, at which time it would be printed out at the end of one of the other reports.

Control policies and procedures. The use of batch totals, turnaround documents, and keyverification are methods of control over the computerized production information system which are discussed above. The topics of data security and input validation as they relate specifically to this system are now addressed.

The focal point of data security in this system must be the production order cost and operations data file. If this file is destroyed, the basis for production scheduling and costing of work in process is lost. A duplicate copy of this tape file should be prepared at the completion of each day's processing. The grandfather-father-son principle should govern the retention of noncurrent versions of this file and the transaction cards and tapes by which it is updated. Internal and external labels identifying the file and the date of expiration of each copy should be used. The tape file ring should be removed from all current versions of the file for protection. When not in use, all current versions of this file should be stored in a tape storage room under the control of a tape librarian, and checking out of the tapes should only be permitted at the scheduled processing times or with special authorization.

Three other master files maintained on tape in this system are the bill of materials file, the operations list, and the finished goods master. Each of these files should also be secured by the use of labels, file protection rings, the grandfather-father-son concept, and the tape library. Working tapes such as the scheduled operations tape, the costed material issues tape, the materials usage data tape, the labor cost efficiency data tape, and the completed jobs tape should be secured while in use by removal of tape file protection rings and the use of internal labels. As transaction tapes, the costed material issues tape and the completed jobs tape should be retained as a provision for reconstruction of the files which they update. However, the scheduled operations tape, materials usage data tape, and labor cost efficiency data tape are only for generating reports, and so need not be retained once preparation of the reports is completed.

Each of the five major file updating programs in the production information system should contain an input validation routine which performs several edit checks on each input transaction. Since each of these processes is performed in sequential order, a sequence check on the input records should always be performed. A validity check of the value in the control field of each input record must always be performed in a sequential file updating program. In addition, when updating the production order cost and operations data file for move tickets and job time tickets, the validity of the operation number, department number, and work station or machine number should be checked. When this file is updated for material issues, the validity of inventory stock number and department number should be checked. These validity checks are accomplished by comparing the values of these items on the input records with the values of the same items in the master record.

Field checks and reasonableness tests should be performed on the values of all numeric items which are not validity checked. The fields involved are: quantity to be produced on the authorization to manufacture records, quantity completed on move tickets, quantity and unit cost on material issues, hours worked, pay rate and quantity completed on job time tickets, and quantity completed and unit cost on finished job records. The reasonableness of values for each of these items is tested by comparison with average or expected values recorded on the master files.

A final set of edit checks is necessary in all programs which update the production order cost and operations data file. In explanation, note that this file includes records of scheduled operations and requisitioned materials which are updated as operations are completed and materials are issued. Because of this, the programs which update the file can be written to detect any unreported operations performed and materials issued. For example, if the completion of operation A has not been recorded, but the completion of operation B which follows A has been recorded, an error exists – either A has been completed but not recorded, or B has been improperly recorded as complete. Similarly, if an issue of materials has not been recorded, but the completion of an operation requiring those materials has been recorded, an error exists. All discrepancies of this type should be reported on the list of error transactions.

Further control over production information processing is accomplished by review and follow-up on the various error transaction reports. This function should be the responsibility of personnel other than operators or programmers, preferably data control personnel or a supervisor. The source of each error transaction should be traced as a means of assuring the accuracy of error corrections and identifying potential weak areas of control. Error corrections should be prepared and submitted to the system as quickly as possible.

Use of disk files. If disk files are used rather than magnetic tape files for some or all of the master files and working data files in this system, processing efficiency could be improved and the system considerably simplified. One such efficiency would result from the elimination of several tape loading and handling steps between processes, since if a disk file is maintained online, its loading is accomplished automatically. In addition, some integration of updating processes could be accomplished. For example, costed materials issues could be posted directly to the production order cost and operations data file on disk as a by-product of the updating of the raw materials inventory master. Similarly, completed jobs could be posted directly to the finished goods inventory master on disk as a by-product of updating the production order cost and operations data file for job time data. Another simplification of the system would be the use of spooling in those runs which have more than one printed output report, such as the run for preparation of production orders and materials requisitions illustrated in Fig. 14.10, and the finished goods file update run shown in Fig. 14.13. Finally, reports such as the finished goods stock status report would not have to be printed out regularly, since any information on this report would be available in current form by means of inquiry into the system from online data terminals. The next section elaborates upon the use of disk files in production information processing within the context of a real-time production information system.

A Real-Time System

In a manual or computerized batch processing system for production information processing, the cycle of planning and control information flows is repeated

primarily daily or weekly. Production scheduling is done daily. Most production orders are initiated at the beginning of each week. Production cost data may be reported daily, weekly, or even monthly. In small firms, an information flow cycle of this length may be acceptable. As firms grow larger, the production management function will employ expediters to monitor production work requiring closer attention than that provided by daily or weekly feedback. At some point in the growth of a manufacturing firm, the use of an online computer system to provide real-time scheduling and control of production operations becomes economically feasible.

A system flowchart of a real-time production information processing system appears in Fig. 14.14. Online input devices are available within each department in the factory. These input devices could be keyboard data terminals, or they could be other types of data collection devices, such as optical readers which can interpret mark sensed cards. Input data entered by factory workers using these devices would include the production order number, operation number, employee number, machine number, and materials quantity of all work performed, both at the time of starting and completing the work. Input data recording the movements of work in process from one work station to another would also be entered by factory personnel.

The production planning and cost accounting departments would also have available data terminals with which access to the system could be gained. The terminals could be used by personnel in these departments to inquire into the current status of work in process. Production planning personnel could use their terminal to initiate special transactions, such as rush orders or requests for issuance of additional materials. Cost accounting personnel could perform various cost analyses on work in process using their terminal.

The online data files in the system include: (1) the production order cost and operations data file, which maintains current data on the operational and cost status of all production orders in process; (2) the machine status data file, which maintains current data on the operations currently being performed and scheduled to be performed on each machine or work station in the factory; (3) the employee data file, which records the work performed by each employee and maintains a record of jobs currently being performed and scheduled to be performed by each employee; (4) the raw materials inventory master file; and (5) the finished goods inventory master file. All of these files are updated in a single integrated process as inputs recording the completion of an operation or the movement of materials are received from the factory.

Because factory workers are prone to make errors in entering input data, the real-time production information system must utilize input validation routines and other techniques for maximizing the accuracy of data collection. Some data collection devices utilize card input, so that cards with some prerecorded data can accompany work in process and be used by each worker to enter input. Other devices can read an employee's number from a specially prepared identification card. Input validation routines can compare entered data with data from

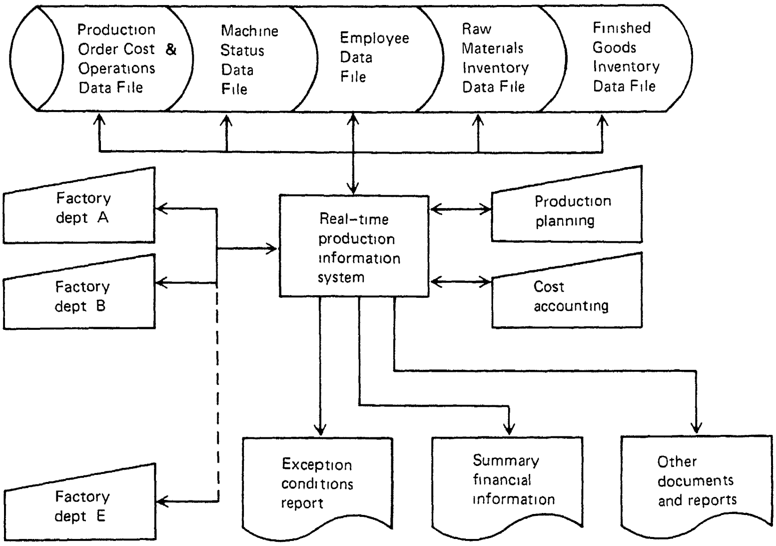


Fig. 14.14 Real-time production information system.

schedules and, if significant differences are discovered, can request the worker to check the data for errors and reenter the data if necessary.

Even in a real-time production information system, the preparation of most production orders and materials requisitions would probably still be a non-real-time process. For this purpose, the operations list and materials specifications list could be maintained on magnetic tape. Authorization to manufacture cards could be used to initiate batch processing operations at the beginning of each week which would prepare production orders and materials requisitions and update the production order cost and operations data file and the raw materials inventory data file.

The primary advantages provided by a real-time production information system involve improvements in the efficiency of operations through better scheduling and faster control reporting. With respect to scheduling, the objectives are to achieve maximum factory throughput and machine utilization while minimizing both the value of work-in-process inventories and the completion time of all orders in accordance with their relative priorities. A batch processing system may only produce one production schedule for each department at the beginning of each day. This schedule has to be flexible in the sense that each foreman is given the freedom to adjust to changing conditions in the dynamic factory environment. Examples of such changing conditions include machine breakdowns, employee absenteeism or illness, operations which are not completed within the scheduled time, faulty materials, introduction of rush orders,

and so forth. A real-time production scheduling system can react immediately to these changing conditions and reschedule operations in an optimum fashion.

With respect to production control, a real-time system can provide online monitoring of critical situations. For example, the system can check the status of rush orders at periodic intervals and prepare a report on any rush orders which are falling behind schedule. Scheduled operations on which no operator has reported starting or completing can be reported to the appropriate foreman. Data input of questionable accuracy can be reported for follow-up and possible subsequent correction. Significant cost overruns can be reported as they occur if desired. Raw materials inventory can be reordered immediately as materials usage lowers available quantities below the reorder point. Current information is always available on the status of work in process in response to inquiries from management or production personnel.

REVIEW QUESTIONS

1. Define the following terms:

   bill of materials
   operations list
   routing sheet
   expediting
   dispatching
   job order costing
   process costing

2. Describe in general the decision responsibilities and information requirements of the production planning function.
3. What are three basic types of standards which must be met in the production operations control function? What information, from what sources, is required in controlling operations to achieve each standard?
4. Identify the two primary information subsystems in production planning and control.
5. What are the accounting journal entries which summarize the activities involved in the production process?
6. Explain the distinction between applied and actual overhead costs. Why is it necessary to use applied overhead costs in production costing?
7. Describe the content and usage of two primary master files in an information system for processing production information.
8. Explain the effect of the type of costing system used by a manufacturing organization upon the data content and organization of its work-in-process master file.
9. What departments in a business organization might be involved in the manual processing of production information? What documents and reports might be used, and what information would each contain? In what department would each document or report originate, and where and for what purpose would each be distributed?

10. What functions must be separated to achieve organizational independence with respect to production information systems?
11. What control policies and procedures are important in a production information processing system?
12. What special control procedures are necessary in a production information system in the event that actual materials usage is greater than or less than the amount originally requisitioned?
13. Describe possible similarities and differences in processing of production information using a computer system rather than a manual one. Emphasize documents, departments, and reports involved in the process.
14. Describe or illustrate how production orders and materials requisitions might be prepared by computer.
15. Explain several ways in which source data automation might be applied to the collection of data on production operations.
16. Describe several control policies and procedures which might be used in batch processing of production information by a typical manufacturing company utilizing a computer system.
17. In what ways could the use of disk file storage instead of magnetic tape simplify file processing in a computerized production information system?
18. Prepare a system flowchart of a real-time system for processing information for production planning and control.
19. What techniques could be used in a real-time production information system to minimize the possibility of acceptance of inaccurate input data?
20. Explain several advantages provided by a real-time production information system.

DISCUSSION QUESTIONS

21. This and the preceding chapter primarily emphasized the logistics information requirements of a manufacturing firm. Discuss the basic similarities and differences in organization structure, information requirements, and data sources between the logistics system of a manufacturing firm and that of
    a) a transportation company, such as a railroad or airline,
    b) a construction company, or
    c) a professional service firm such as a public accounting partnership.
22. Would it be worthwhile for a manufacturing firm to have a real-time system which reports production cost variances on an hour-by-hour basis? Discuss.

PROBLEMS AND CASES

23. What control policies and procedures in a production information system would provide the best control over the following situations?
    a) Initiation of a production order for a product for which demand no longer exists.
    b) Theft of items of in-process inventory by a production employee.
    c) The "rush order" tag on a partially completed production job became detached from the materials and lost, causing a costly delay in completing the job.
    d) A production employee prepared a materials requisition, used the document to obtain $300 worth of parts from the parts storeroom, and stole the parts.
    e) A foreman's insistence that every man in his department must learn to use every machine in his department resulted in an increase in the proportion of work done by the department which failed to pass quality control tests.
    f) A production worker entering job time data over a terminal mistakenly entered 3000 instead of 300 in the quality completed field.
    g) A dishonest parts storeroom employee issued quantities of parts 10% lower than indicated on several materials requisitions, and stole the excess quantities.
    h) Incorrect keypunching of the production order number from a materials requisition caused a materials issue to be posted to the wrong production order.

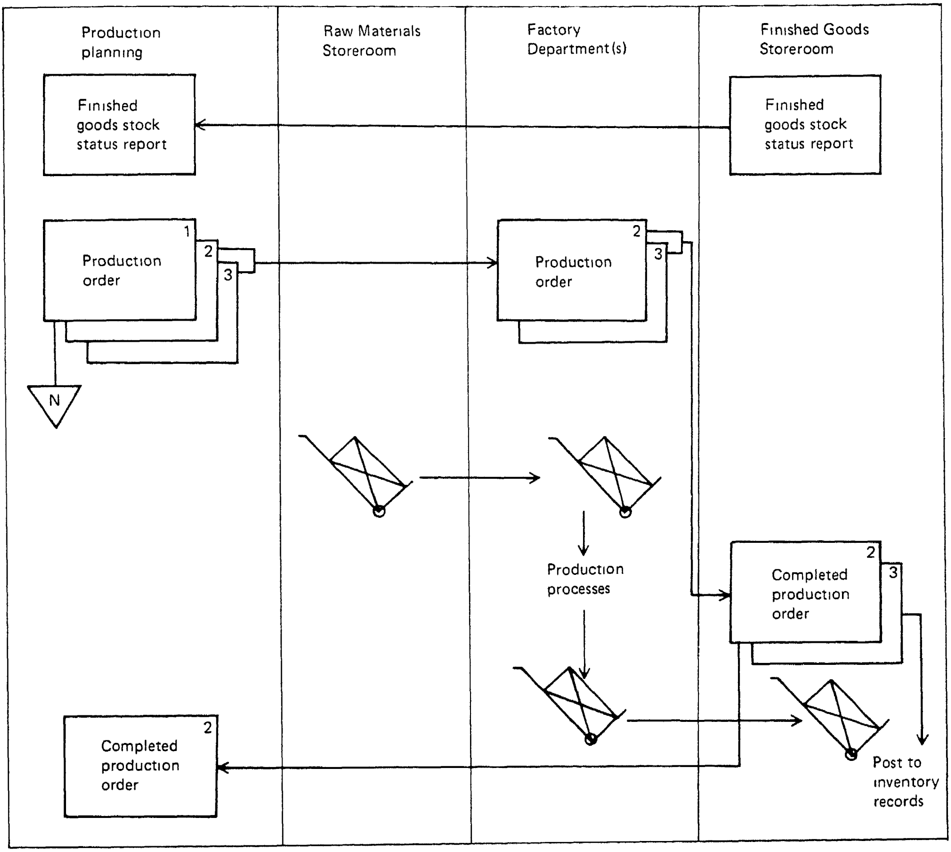
24. The Make-Shift Typewriter Company has a repair department which does work on machines brought in to it by customers. This department has its own stockroom for parts and supplies. The controller of the company believes that the department foreman and the servicemen are helping themselves to a considerable amount of parts and supplies from the stockroom. Describe, briefly, a system which would provide control over the parts and supplies inventories.

25. Assume that you are a management consultant for a large public accounting firm. One or your firm's clients is the Willard Corporation, a medium-sized manufacturing firm. Willard's Controller has recently come to you for advice regarding the following problems:
    - The proportion of customer orders filled by the promised delivery date has declined from 90% to 50% within the past year.
    - Production costs have risen dramatically due to increased charges for overtime, rework, and idle time waiting for materials or machines.
    - The company has doubled the number of expediters employed from three to six with no noticeable improvement in the problems.

    What are some important questions which you would ask the Controller in attempting to gain insight into these problems? Relate your ques-

tions specifically to the company's production information system and its approach to production management.

26. Shown below is a document flowchart of data flows relating to production operations for the April Manufacturing Company.



Required:

a) Describe several deficiencies in internal control in the above system. For each deficiency, indicate an error, manipulation, or inefficiency which could result.

b) Indicate the best means of remedying each deficiency described in part (a).

27. The Caesar Manufacturing Company uses sheet metal and other uncut and unshaped raw materials in its production process. Accordingly, control of materials usage and spoilage is a significant management problem. The company utilizes a standard cost system which specifies standard materials

usage for each operation performed in production. Each departmental foreman is responsible for materials usage variances arising from operations performed by the employees under his supervision on the machines in his department. The primary means of control available to foremen are the assignment of employees to machines and supervision of employee work.

Required:

Design a format for a daily materials usage report for a factory department. Make any reasonable assumptions about the availability of data for inclusion in the report. Make sure that you take into account the need to relate the report to the foreman's objectives and decision alternatives. The report should present the vital information effectively and use the principle of management by exception.

28. Consider the real-time production information processing system described in this chapter and illustrated in Fig. 14.14.
    a) What data must be included in a job time record which is used to update the production order cost and operations data file, the machine status data file, and the employee data file? Be sure to distinguish between data which may already be available in the files and data which must be entered by the worker.
    b) Prepare a program flowchart of an input validation routine which checks the accuracy of each item of data in the input record.
29. The Gibson Manufacturing Company utilizes an online production information system which has access to the following files stored on an online disk unit:
    a) A production order file, which keeps track of the operations performed and still to be performed, the quantities in process, and the accumulated materials, labor and overhead cost for all outstanding production orders.
    b) A finished goods inventory file, which includes data on the quantity and production cost of all finished products in stock.
    c) An employee data file, which is keyed by employee number and includes the employee's pay rate and all other essential payroll data.

    One of the programs in this system processes data on completed operations entered by factory employees using terminals. For each operation completed, the following data are entered: production order number, operation number, employee number, quantity completed, start time, and stop time. The program performs various edit checks and validity checks on data entered. If the input is valid, the program updates the production order record for completion of the operation and corresponding labor cost data. If the operation represents the completion of the entire production order, the program updates the finished goods inventory file for the completed stock, writes a completed production order cost summary report on

a separate disk file for subsequent processing by another program, and removes the completed production order record from the production order file.

Required:

Prepare a macroflowchart of the program described above. Assume that the checking of whether or not the input data is valid represents one macrostep. Show all necessary input and output steps, and each major decision and processing step, as required to complete the necessary processing.

30. Processing of production orders in the Monahan Manufacturing Company is performed as follows. At the end of each week the production planning department prepares a list of products and quantities to be produced during the next week. Authorization to manufacture cards are keypunched from this list, sorted by production order number, and processed together with an operations list file on magnetic tape to generate production orders. For each new production order, the program: (1) prepares three copies of a production order document, (2) writes the production order onto a disk file of open production orders, and (3) punches an operations card for each operation to be performed on the production order.

    The operations cards are used as turnaround documents. They are distributed to the factory departments where each operation is to be performed. After completing an operation, factory employees mark the elapsed time, quantity completed, etc. on the card and submit it to the data processing center. There a reproducer is used to mark sense and punch the data entered by the factory employees into the card. The cards are converted to magnetic tape using an offline converter. The magnetic tape records are then sorted by production order number and processed to update the open production order master. After the master has been updated for all completed operations, the program generates departmental production schedules for the next day.

    Required:

    a) Prepare a systems flowchart of all operations described.
    b) Describe several control policies and procedures which should be incorporated into this computerized system. Indicate the purpose of each policy or procedures. Relate your answer specifically to the computer-related activities described in the case.
    c) Explain how departmental production schedules may be generated from the updated production order master file without sorting that file by department number.

Chapter 15

Accounting Information Systems for Personnel Management

Personnel management involves planning, coordinating, and controlling the use of human resources within an organization. Information systems for personnel management are concerned with the processing of information about people within an organization — their recruitment, training, safety, and compensation. The accounting information system generates much useful information to personnel management through systems for processing employee payrolls. This chapter briefly reviews the personnel management function, discusses the nature and sources of personnel information, and finally explores in more detail the payroll processing system.

THE PERSONNEL MANAGEMENT FUNCTION

A typical organization structure for the personnel management function is illustrated in Fig. 15.1. However, the personnel management function in an organization does not take place entirely within the personnel organization. Every supervisor within an organization plays a major role in the management of the personnel under his supervision. In this sense, the personnel management function is the most decentralized of all of the management functions. The personnel organization is responsible for those personnel management activities which are most conveniently performed on a centralized basis. This section will review the personnel management responsibilities and related information requirements of the typical departmental supervisor, as well as of the top personnel executive and the various personnel staff functions.

The Top Personnel Executive

The place of the top personnel executive in the organizational structure varies from company to company. In some companies, he is a vice president with status equal to that of the vice presidents for production, marketing, and finance. In other companies he reports to the vice president for production. In the latter case his responsibilities would primarily involve production employees, and

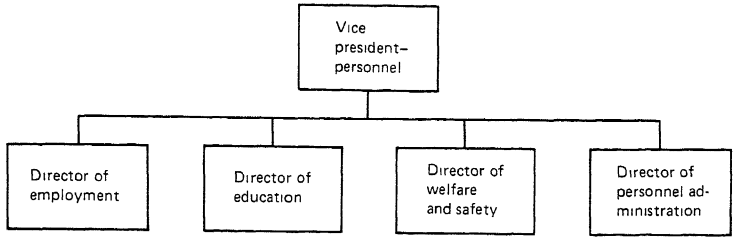


Fig. 15.1 Personnel organization structure.

executives in other functional areas would hold primary responsibility for personnel management within their respective areas.

Because of the increasing recognition of the importance of human resources to the business organization, the top personnel executive is increasingly being accepted as a participant in top management planning for corporate resource allocation. In this role he contributes a perspective on the personnel management implications of corporate plans for expansion or cutting back of operations. The formal output of this process should be a manpower plan, which forecasts the organization's needs for personnel of various skills and levels of education and experience.

The top personnel executive is also responsible for the administration of the various personnel staff functions. The manpower plan provides a basis for planning and controlling the activities of employment and education and training. Major decisions in the areas of welfare and safety and personnel administration require the approval of the top personnel executive. The development of a personnel management organization, the delegation of authority to carry out personnel management activities, and the monitoring of performance of those activities are further administrative functions of the top personnel executive.

In addition, the top personnel executive is responsible for developing recommendations to top management concerning company-wide personnel policies. Examples of such policies include hiring practices, job performance standards, health and safety standards, and wage and salary plans. If the firm's employees are unionized, the top personnel executive will often have primary responsibility for conducting collective bargaining negotiations for management.

The information needs of the top personnel executive are broad. On the one hand, he requires quantitative information concerning the number of existing employees in various skill and experience categories, trends in hours worked, efficiency, accident rates, turnover and absenteeism, future manpower requirements, cost of alternative wage and salary proposals, existing labor market conditions, and so forth. Formal organization systems are typically designed to fulfill many of these information requirements. On the other

hand, the top personnel executive requires qualitative information involving such factors as employee motivation, morale, abilities, interpersonal relationships, etc. Factors of this sort are not as easily evaluated by formal information systems. However, information of this type is one of the primary products of informal information channels within an organization.

The Personnel Staff Functions

The personnel staff functions of employment, education and training, welfare and safety, and personnel administration are primarily administrative service functions, rather than decision making functions. The primary responsibilities of each of these staff functions are reviewed briefly here.

The Director of Employment is responsible for such activities as the development of job specifications, recruiting, interviewing and testing of potential employees, and maintaining files of job applicants. He is also in charge of hiring, placement, and counseling, and may play a role in decision making with respect to promotions, transfers, and terminations. His information requirements are both internal and external. His primary internal information need concerns manpower requirements within the firm – both job specifications and quantity requirements. His primary external information need concerns sources of manpower, such as employment agencies, training schools and college placement offices.

The Director of Education and Training is responsible for developing the skills of personnel at all levels of the organization. At the lowest level this involves the training of machine operators and clerks. At a higher level it encompasses the training of supervisors and staff personnel. At its highest level it concerns the development of executive skills and experience. Essential to the administration of training programs are such factors as: organizing and planning of the training program; development of training materials; selection of trainees, instructors, and training site; and evaluation of results. Administration of executive programs includes determination of desired executive capabilities, selection of candidates, choosing a program of development, and evaluation of results.

The Director of Welfare and Safety is responsible for establishing and enforcing health and safety standards within the organization. With respect to health, this function involves maintaining employee medical records, administering physical examinations at the time of employment and periodically thereafter, and providing first aid and other medical services. With respect to safety, such matters as the establishment of safety rules, planning for the use of protective clothing and mechanical safeguards, administering a program of safety education, and investigating the causes of accidents are involved.

The personnel administration function encompasses a variety of personnel services. These include profit sharing and pension plans, group insurance plans, employee credit unions, plant cafeterias, and employee suggestion plans. The function also includes the maintenance of an up-to-date record on all employees within the organization.

The Departmental Supervisor

Each departmental supervisor within an organization is directly responsible for the day-to-day planning, coordination, and control of his employees. He must organize the tasks to be performed, assign employees to jobs, coordinate their activities, motivate them, monitor their performance, evaluate their abilities, provide on-the-job training, and enforce company policies.

Much of the information required by the departmental supervisor to perform his personnel management function may be obtained simply from observation and experience. However, the formal information system provides him with useful supplementary information. This would include statistics concerning the productivity (output per man hour) of each employee at each job within the department. Among other useful information regarding individual employees are: rate of absenteeism and tardiness, quality of work performed, and level of skills. Qualitative assessments provided by other employees or supervisors concerning personality and character may also be useful.

SOURCES OF PERSONNEL INFORMATION

The primary sources of personnel information are the accounting information system and the personnel department. Personnel information is also obtained from other sources inside the business organization as well as from external sources. This section reviews the nature of the information available from each of these sources.

The Accounting Information System

The payroll processing system is the traditional channel within which personnel information is generated from accounting data. The human resource accounting system is a new channel for such information, and is in fact used in only a very small number of companies, primarily on an experimental basis. Both of these systems are discussed here; the payroll processing system is discussed in greater detail in a subsequent section. Cost estimation for wage negotiations is a third source of accounting information for personnel management discussed in this section.

The payroll processing system. With respect to the processing of factory payrolls, the two basic input documents are the job time card and the employee clock card. The nature and use of the job time card as a source of data for labor cost distribution is described in Chapter 14, and two examples of job time cards are illustrated in Figs. 14.8 and 14.12. The employee clock card, illustrated in Fig. 15.2, indicates the total number of hours the employee spends at work each day. This document serves as the basic input to the payroll calculation and paycheck preparation function.

With respect to the processing of payrolls for clerical, sales, and salaried employees, the nature of data input is somewhat different. Since administrative

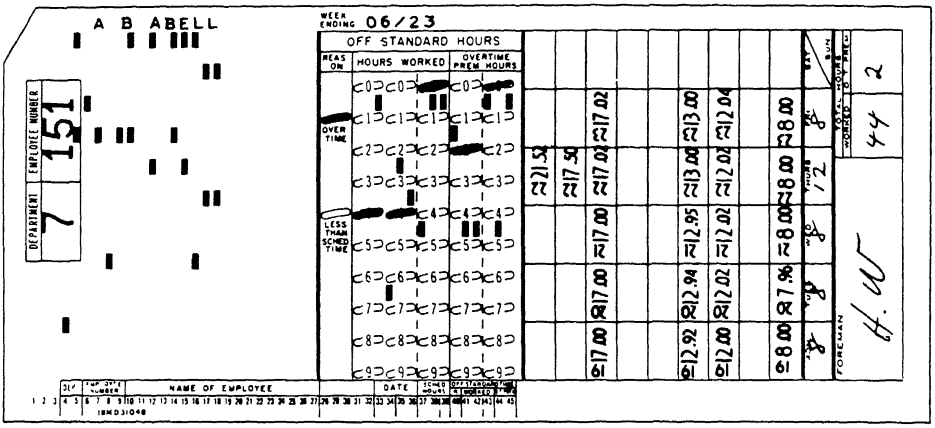


Fig. 15.2 Employee clock card. (Reprinted by permission from *Basic Applications - System/360 Model 20.* Copyright © 1971 by International Business Machines Coproration.)

and selling expenses are not charged to production in process, the job time card is not used. However, a form similar to a job time card may be used if administrative expenses are charged to specific projects, such as a software development project, a sales promotion, or a research and development project. The employee clock card may be used for those clerical employees who are paid on an hourly basis, but is not needed for those paid a salary. The monthly gross pay of a salaried employee is a known constant, except in those cases where some salaried employees are paid for overtime work. For salesmen paid on a commission basis, sales data are required for payroll processing.

Another basic class of inputs to the payroll processing system includes additions, deletions, and adjustments of various kinds to employee payroll records. The category of adjustments includes salary or wage rate changes, address changes, departmental transfers, changes in tax exemptions, changes in deduction authorizations, and so forth. The volume and variety of these transactions is often quite large.

Among basic outputs of payroll processing are employee paychecks and earnings statements and various reports required by governmental authorities. However, a variety of useful personnel information may be generated as a by-product of payroll processing. Reports which measure employee efficiency or productivity are one example. From the job time cards, the average time spent by each production employee in performing each job operation can be determined. For each operation the average time spent by all employees in performing that operation can be derived. If a standard cost system or work measurement system is used, a comparison of average actual time to standard time provides a measure of the efficiency with which each operation is being performed. The relative efficiency of each employee can be generated by taking a weighted average of his efficiency in all of the various operations he

has performed. Finally, the aggregation of these statistics by department provides a measure of departmental efficiency which is useful in evaluating the performance of departmental foremen. If a standard cost system is employed, efficiency measures in the form of labor cost variances can also be provided. An example of a report containing information of this type has been illustrated previously in Fig. 14.3.

Several other types of reports and analyses may be generated from payroll processing. These include: reports of absenteeisn and tardiness by employee, analyses of indirect labor by type of cost – supervision, materials handling, inspection, etc. – and by department, reports on actual and standard labor cost for completed production orders, analyses of overtime pay by department, analyses of fringe benefit costs, and reports on sales commission expenses. Also valuable in manpower planning are certain aggregate statistics accumulated during payroll processing, such as total number of employees, total hours worked, total labor cost, average wage rate, rate of absenteeism, rate of turnover, and average and total fringe benefit costs. These statistics are most meaningful when trends in their values are analyzed and correlated with each other and with other factors. For example, useful management information may be obtained from correlating the rate of turnover with average hours worked per employee, or the rate of absenteeism with the number of units which fail to pass quality control inspection.

Human resource accounting. The basic philosophy of human resource accounting is that human resources are assets, and that the investment in acquiring and developing these resources should be accounted for as an asset. Expenditures for hiring and training, which would be expensed in conventional accounting systems, are capitalized and allocated to individual employees. As with the cost of other assets, this cost is amortized over the expected useful life of the asset. If an employee is terminated, the net investment in him is written off as a loss.

Useful information for manpower planning is provided by the human resource accounting system. The year-to-year change in the total balance of the human resources account (annual investment minus amortization and turnover losses) provides an indication of management's performance in maintaining and developing human assets. Adding the human resources account into the total asset base may provide more significant measures of return on investment. Information concerning the probable loss of human resources is useful to decisions regarding employee layoffs. Finally, capital investment information may be more meaningful if each investment proposed includes an analysis of the human resources which must be invested in the project and those which will be consumed by the project.

Human resource accounting is a new and unconventional technique. It is not recognized for tax purposes or for financial reporting under generally accepted accounting principles. Its use imposes additional requirements for data collection and processing, record keeping, and reporting upon accounting information systems. Despite these disadvantages, human resource accounting

seems likely to become an important element of accounting information systems in an age where human knowledge and ability is recognized as being of critical importance to the modern business organization.[1]

Cost estimation for wage negotiations. Contract negotiations with labor unions require management to make trade-offs between such factors as the wage rate, paid vacations, paid holidays, contributions to employee insurance and pension plans, overtime premiums, and so forth. Each of these factors has a cost, and management should be provided with estimates of the cost implications of various alternative contract proposals to use as a basis for bargaining. Cost accountants and payroll accountants are in the best position to develop such estimates, and should therefore participate in this aspect of collective bargaining. Accounting systems should be designed to facilitate the preparation of whatever kinds of information management deems useful for this purpose.[2]

The Personnel Department

Much valuable information for personnel management is generated by and maintained within the personnel department. One of the best sources of information is the personnel data file, in which is maintained a complete record of each employee in the organization. This record includes such data as the physical characteristics of the employee, his background of education and experience, basic payroll information, quantitative and qualitative evaluations of his past performance, state of health and medical history, results of tests of ability and aptitude, and so forth. This data file provides a basic source of information for decisions regarding assignment of employees to positions, approval of raises and promotions, and selection of supervisory and management trainees. If properly organized to facilitate information retrieval and aggregation, the employee data base can also be a useful tool for company-wide manpower planning.

Other information developed and maintained by the personnel department includes: job specifications, which detail the training and experience required to qualify for each job in the organization; aggregate safety and accident statistics; forecasts of manpower requirements by job category within the organization; and records and statistics concerning training programs, health services, employee credit unions, and other employee services.

Other Internal Sources

One of the primary sources of personnel information is the departmental supervisor, who is responsible for providing merit evaluations of the employees

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[1] For further discussion of human resource accounting, see R. Lee Brummet, Eric G. Flamholtz, and William C. Pyle, "Human Resource Accounting – A Challenge for Accountants," *The Accounting Review*, April, 1968, pp. 217-224.

[2] For an extensive treatment of this topic, see Harry C. Fisher, *The Uses of Accounting in Collective Bargaining* (Institute of Industrial Relations, University of California, Los Angeles, 1969).

under his supervision. These are basically qualitative evaluations of such factors as personality, initiative, attitude, judgment, character, and so on. Departmental supervisors also supply the personnel department with information concerning the manpower requirements of their department in terms of the number of employees required and the desired qualifications.

Other functional departments within the firm may also contribute worthwhile information for personnel management. For example, the engineering department may develop job time standards for use in evaluating employee performance. The legal department may provide advice concerning legal aspects of employee relations. The economics department may provide special studies of labor market conditions and their implications for hiring policies or wage negotiations.

External Information Sources

External sources of information for personnel management include employment agencies, labor unions, vocational and training schools, university placement offices, and various governmental agencies. Information regarding potential employees may be obtained from employment agencies, schools, personal references, and in some cases from labor unions. Labor unions also serve as a spokesman for employees with respect to their satisfaction with the existing labor contract, and the topics which will most concern them during negotiation of the next contract. Various agencies of state and federal government often make available research studies or statistical compilations concerning such factors as labor market conditions, prevailing wage rates, levels of unemployment, industry accident rates, and so forth. College placement offices provide statistics on expected number of graduates by area of specialization. Personnel managers must be familiar with all of these various external sources of personnel information.

THE PAYROLL PROCESSING SYSTEM

The general nature of the input to and output from payroll processing has already been reviewed. This section will outline the accounting transactions involved in the process, describe in detail the data maintained in the payroll master file, and then explore in some depth examples of a manual payroll system and a computer based payroll system.

The Accounting Transactions

There are two basic accounting journal entries which reflect payroll processing. The first of these shows payroll cost distribution to various expense and inventory accounts:

Work-in-Process Inventory	XXX	
Manufacturing Overhead	XXX	
General and Administrative Expense	XXX	
Payroll		XXX

The debit portions of this entry are classified according to the type of cost and the department number of the employee, and are accumulated for purposes of preparing departmental cost performance reports. The work-in-process portion of the entry is further classified and accumulated by production order as explained in Chapter 14.

The second of the two basic accounting journal entries in payroll processing reflects the payroll calculation and paycheck preparation process:

Payroll	XXX	
Federal Income Tax Witheld		XXX
F.I.C.A. Tax Withheld		XXX
State Income Tax Withheld		XXX
Group Insurance		XXX
Cash		XXX

The deduction accounts shown in the entry represent the most common payroll deductions. After the payroll preparation is completed, the total balance in each of these liability accounts is paid with a single check. The credit to cash represents the total of all employee paychecks issued. The debit to the payroll control account in this entry should be exactly equal to the total credit to this account in the previous entry.

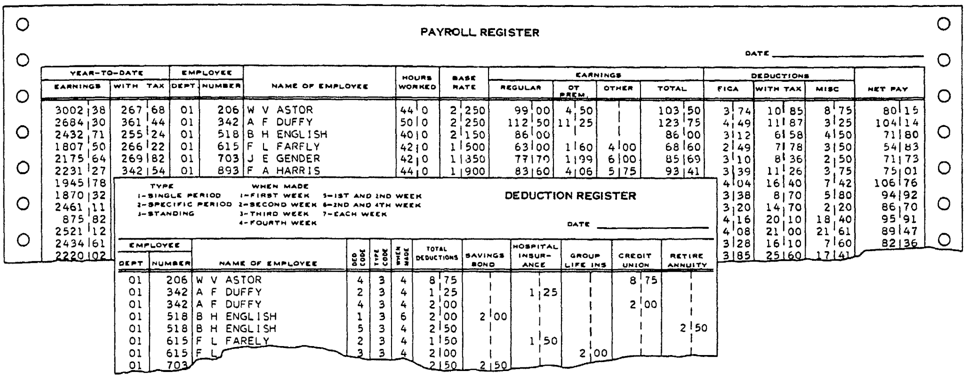
The Master Files

The primary master file maintained for purposes of payroll processing is the payroll master file. In addition, several other master files which are updated for labor cost and time data as a result of payroll processing include (1) the work in process master, (2) the production order master, (3) the factory overhead ledger, (4) the general and administrative expense ledger, and (5) the selling expense ledger. The first two of these other files are covered in Chapter 14, the remainder in Chapter 16.

The typical data content of the payroll master file is listed in Fig. 15.3. Several items in the illustration require further explanation. The "type of cost" code in the account number indicates the nature of the account to which the employee's gross pay is charged — direct labor, indirect labor, sales commission, etc. The number of exemptions claimed and marital code allow the employees' witholding taxes to be computed with reference to tax tables. The several fields indicating the amount of an authorized deduction per week (or month) might include retirement plan contributions, group life and hospitalization insurance premiums, savings bond purchases, union dues, etc. The amount of each of these deductions should be a constant from period to period, and these fields in each employee record will contain a dollar amount for that employee. The several fields containing year-to-date totals include gross pay, net pay, Federal Income Tax withheld, other tax withholdings, and all other deductions.

Employee number (control field)
Name
Job title
Account number - department code
Account number - type of cost code
Social Security number
Number of exemptions claimed
Marital code
Wage rate (or salary)
Amount of each authorized deduction (several fields)
Year-to-date earnings totals (several fields)

Fig. 15.3 Data content of payroll master file.



PAYROLL REGISTER

DATE ____________

YEAR-TO-DATE EARNINGS	YEAR-TO-DATE WITH TAX	EMPLOYEE DEPT	EMPLOYEE NUMBER	NAME OF EMPLOYEE	HOURS WORKED	BASE RATE	EARNINGS REGULAR	EARNINGS OT PREM.	EARNINGS OTHER	EARNINGS TOTAL	DEDUCTIONS FICA	DEDUCTIONS WITH TAX	DEDUCTIONS MISC	NET PAY
3002 38	267 68	01	206	W V ASTOR	44 0	2 250	99 00	4 50		103 50	3 74	10 85	8 75	80 15
2684 30	361 44	01	342	A F DUFFY	50 0	2 250	112 50	11 25		123 75	4 49	11 87	3 25	104 14
2432 71	255 24	01	518	B H ENGLISH	40 0	2 150	86 00			86 00	3 12	6 58	4 50	71 80
1807 50	266 22	01	615	F L FARFLY	42 0	1 500	63 00	1 60	4 00	68 60	2 49	7 78	3 50	54 83
2175 64	269 82	01	703	J E GENDER	42 0	1 350	77 70	1 99	6 00	85 69	3 10	8 36	2 50	71 73
2231 27	342 54	01	893	F A HARRIS	44 0	1 900	83 60	4 06	5 75	93 41	3 39	11 26	3 75	75 01
1945 78											4 04	16 40	7 42	106 76
1870 32											3 38	8 70	5 80	94 92
2461 11											3 20	14 70	2 20	86 70
875 82											4 16	20 10	18 40	95 91
2521 12											4 08	21 00	21 61	89 47
2434 61											3 28	16 10	7 60	82 36
2220 02											3 85	25 60	17 41	

DEDUCTION REGISTER

TYPE
1-SINGLE PERIOD
2-SPECIFIC PERIOD
3-STANDING

WHEN MADE
1-FIRST WEEK
2-SECOND WEEK
3-THIRD WEEK
4-FOURTH WEEK
5-1ST AND 2ND WEEK
6-2ND AND 4TH WEEK
7-EACH WEEK

DATE ____________

EMPLOYEE DEPT	EMPLOYEE NUMBER	NAME OF EMPLOYEE	DED CODE	TYPE CODE	WHEN MADE	TOTAL DEDUCTIONS	SAVINGS BOND	HOSPITAL INSUR-ANCE	GROUP LIFE INS	CREDIT UNION	RETIRE ANNUITY
01	206	W V ASTOR	4	3	4	8 75				8 75	
01	342	A F DUFFY	2	3	4	1 25		1 25			
01	342	A F DUFFY	4	3	4	2 00				2 00	
01	518	B H ENGLISH	1	3	6	2 00	2 00				
01	518	B H ENGLISH	5	3	4	2 50					2 50
01	615	F L FARELY	2	3	4	1 50		1 50			
01	615	F L	3	3	4	2 00			2 00		
01	703					2 50	2 50				

Fig. 15.4 Payroll and deduction registers. (Reprinted by permission from *Basic Applications-System/360 Model 20.* Copyright © 1971 by International Business Machines Corporation.)

The payroll master file is updated once at the end of each payroll period for all adjustments to employee records, additions, deletions, and time worked data for hourly employees. The output of this process includes employee paychecks and earnings statements and a *payroll register*, which is a listing of payroll data for each employee for the current payroll period. A separate *deduction register* may also be prepared detailing the miscellaneous deductions of each employee. These two reports are illustrated in Fig. 15.4. At intervals other than during payroll preparation, the payroll master file is used to prepare various reports for managers and the government.

A Manual System

Figure 15.5 illustrates one example of a manual system for processing a factory payroll. Unless otherwise indicated in the discussion, the flowchart is also appli-

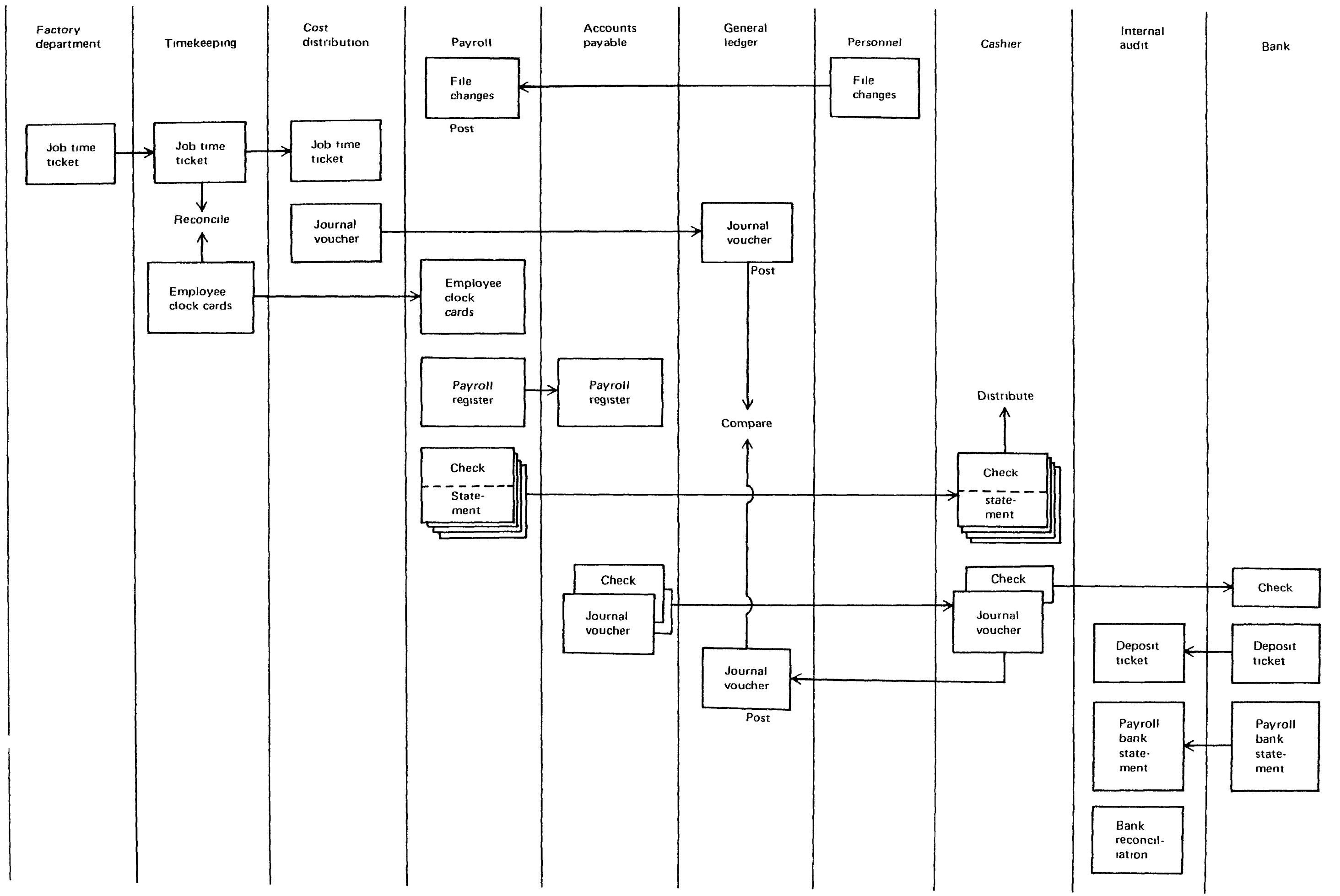


Fig. 15.5 Document flow in a manual system for payroll processing.

cable to the processing of an office employee payroll. The payroll master file is maintained by the payroll department. Terminations, hirings of new employees, changes in employee wage rates, tax status, or deduction authorizations and any other changes in this file which affect payroll preparation, must be approved by the personnel department, which also maintains a record of this data for each employee in the personnel data file. Good internal control requires that the internal audit department periodically compare the payroll data in the payroll master file with that in the personnel file to prevent unauthorized changes in the payroll master.

Regular payroll processing begins with the collection of employee time worked data. The flowchart illustrates this process with respect to factory employees. The job time ticket is filled out by each employee for each job upon which he works during the day. For control purposes, each job time ticket should be verified and signed by the departmental foreman.

Each day the job time tickets are transmitted to the timekeeping department where they are reconciled to the employee clock cards. The clock cards are generally prepared by using a time clock upon which employees punch in and out of work. The reconciliation step is a check that the total time spent at work by each employee is equal to the sum of the time spent on all production orders upon which the employee worked during the day. This internal check helps to assure the accuracy of input data regarding time worked by factory employees prior to its use in various subsequent processing steps.

Time worked data for salaried employees does not need to be provided to the payroll department. Time worked data for factory service department or office employees who are paid on an hourly basis is generally provided by use of a time clock or by departmental supervisors. If salesmen are paid by commission, the payroll department must receive the required input from one of the marketing or sales departments.

After reconciliation to employee clock cards, the job time tickets are provided to the cost accounting department for purposes of payroll cost distribution. At this point, direct labor costs are allocated to the various work-in-process accounts, and a journal voucher recording a debit to work-in-process inventory and credit to payroll is initiated and transmitted to the general ledger clerk. As explained in Chapter 14, applied factory overhead may also be calculated at this point, and would therefore be included on this journal voucher. The distribution of payroll costs to the various subsidiary ledger accounts of the manufacturing overhead ledger, the selling expense ledger, and the general and administrative expense ledger is not shown on the chart. This function is typically performed by the payroll department in a manual system, which department would then also be responsible for preparing the journal voucher summarizing the distribution.

Employee clock cards are provided to the payroll department where, together with the payroll master file, they provide the basis for preparation of employee paychecks and the payroll register. Once gross pay and all deductions have been computed and entered into the payroll register, net pay can be deter-

mined. When preparation of the payroll register is completed, the accuracy of net pay calculations is checked by cross-footing, or determining the sum of the gross pay, net pay and deductions columns for all employees and then comparing total gross pay with the sum of total net pay and deductions. Following this internal check, the individual paychecks and earnings statements are prepared and transmitted to the cashier for distribution to employees.

Next the payroll register is provided to the accounts payable department. On the basis of the column totals of the payroll register, a journal voucher recording the debit to the payroll control account and credit to cash and the various deduction accounts is prepared. At the same time, a check is prepared which authorizes the transfer of the net pay total from the firm's regular bank account to its payroll bank account. This check and journal voucher are provided to the cashier, who signs and deposits the check and forwards the journal voucher to the general ledger clerk. The payroll register is retained to provide an audit trail of the payroll process.

At this point, the general ledger clerk has received two journal vouchers. One records a debit to the payroll control account for the gross pay of factory employees, and the other a credit for the same item. The amount of these two entries to the payroll control account should be exactly equal. If the amounts are not equal, an error has occurred either in direct labor cost distribution or paycheck preparation, and the error must be discovered and corrected. This form of internal check is called a "zero balance check" because the balance of the payroll control account should be zero after these entries are made. Similar checks could be made on the payroll distribution to manufacturing overhead, selling expense, and general and administrative expense.

The use of a separate payroll bank account improves internal control because it facilitates the preparation of bank reconciliations. It is much easier to prepare two separate reconciliations, and to trace down the source of any discrepancies, than to prepare one large reconciliation of a single account. Periodically the internal audit department must prepare the reconciliation of the payroll bank account. The payroll bank statement, deposit tickets, and cancelled paychecks provide a basis for this function.

Organizational independence with respect to payroll processing is achieved by the multitude of functional separations which exist in the system. Perhaps the most significant of these is the separation of timekeeping from payroll preparation, which tends to prevent errors or manipulations involving submission of time data for terminated or nonexistent employees. This type of error or manipulation is also inhibited by separation of payroll preparation from paycheck distribution, together with special procedures for handling unclaimed paychecks. Separation of the personnel function from the payroll preparation function, along with periodic comparison of the payroll records of both functions, tends to prevent errors or manipulations with respect to the payroll master file. Separation of the timekeeping function from the factory departments tends to prevent errors or manipulations involving input data for factory

employees. Separation of the cost distribution and payroll preparation functions tends to prevent errors or manipulation in the distribution of payroll costs or the calculation of gross pay. Finally the separate internal audit function provides an independent check on the operation of the entire payroll system.

Special control procedures are necessary in a payroll processing system for handling unclaimed paychecks. If paychecks are distributed by hand to employees, unclaimed paychecks for terminated or absent employees will be fairly common. Even if paychecks are distributed by mail, some may occasionally be returned for lack of a forwarding address. In any event the unclaimed paycheck indicates the possibility of manipulation. The internal audit department should trace the preparation of such paychecks back to the original timekeeping records, and should check the payroll master file against the personnel master in all such cases. The internal audit department should make further attempts to distribute such checks to the proper persons, and if unsuccessful should lock them up for safekeeping and eventually destroy them.

The internal audit department is also responsible for certain other internal control activities with respect to payroll processing. A sample of payroll calculations may be reviewed in detail for each payroll period. Payroll calculations of paychecks for employees of the payroll department should frequently be reviewed in detail. Periodically internal audit personnel should take charge of the distribution of paychecks to employees to assure that all paychecks prepared are being received by bonafide employees.

The payroll processing function is one of the most time-consuming clerical functions in many organizations. In a manual payroll processing system it may be difficult to both complete payroll preparation and cost distribution and generate useful reports concerning labor costs, production efficiency, an so forth. Several devices have therefore been developed to facilitate payroll processing. One example is the payroll board, which is a type of peg board designed so that several records may be written simultaneously using carbon paper. An example is illustrated in Fig. 15.6. In the board shown in the illustration, data written onto the employee earnings statement is simultaneously written onto the employee payroll master record and the payroll register. This data would include the employee's name and number, the date, hours worked, gross pay, itemized withholdings, other deductions, and net pay. Certain other data, such as check number and year-to-date earnings totals, are simultaneously written onto the employee payroll master record and the payroll register. The payroll cost distribution is entered only in the payroll register.

Bookkeeping machines are also frequently applied to payroll processing. The bookkeeping machine can also be used with carbon paper to simultaneously write the paycheck and earnings statement, updated payroll master record, and payroll register. In addition, it performs the calculation of gross pay and tax deductions. It can also be applied to payroll cost distribution and to preparation of a limited number of reports on such factors as labor cost and productivity.

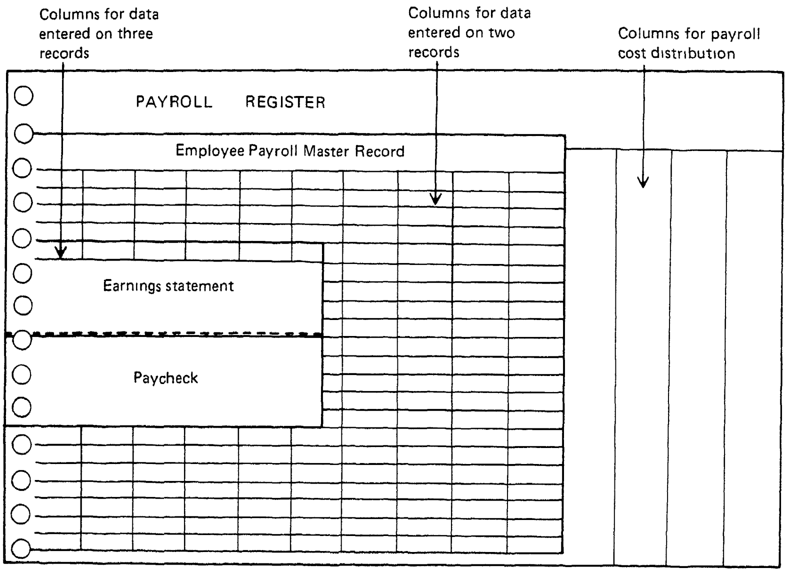


Fig. 15.6 Payroll board for simultaneous writing of payroll records.

A Computer Based Batch Processing System

Because of the volume and complexity of payroll processing, and the routine nature of payroll calculations and records, this operation has generally been one of the first to be computerized in most organizations. A document flowchart of a computer based system for processing a factory payroll in a typical manufacturing company appears in Fig. 15.7. It is assumed that the payroll processing is performed in batch mode using punched card input and magnetic tape file storage. A comparison of this system with its manual counterpart of Fig. 15.5 reveals that the computer has replaced the functions of cost distribution and payroll preparation, but that many of the other functions remain unchanged.

The payroll master file is maintained by the computer operations department on magnetic tape. File changes must be authorized by the personnel department, and are then transmitted to the input preparation department for keypunching. Job time tickets and employee clock cards are prepared in the same manner as described for the manual system, but both of these input documents are also routed to input preparation for keypunching.

As in the manual system, employee checks and earnings statements are sent to the cashier for distribution to employees. At the same time, the payroll register is sent to the cashier, who prepares the check to authorize transfer of funds to the payroll bank account. The journal entry printouts are provided to the general ledger clerk for posting. As in the manual system, the internal audit section is responsible for preparing a reconciliation of the payroll bank account.

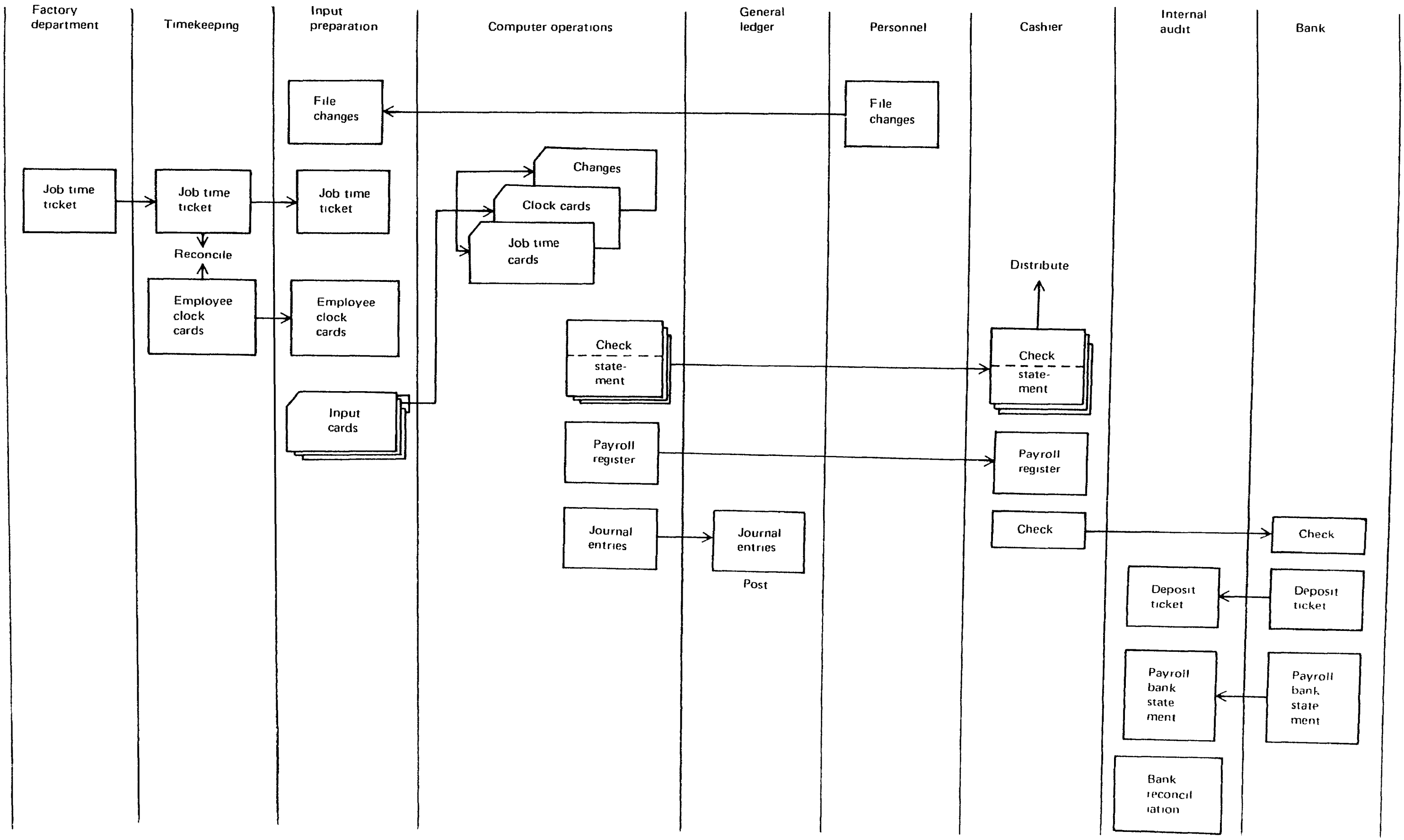


Fig. 15.7 Document flow in a computerized batch processing system for payroll processing.

After the various input cards have been keypunched and verified, they are taken to computer operations for processing. The computerized processing of job time cards to update records of cost and operations performed for production in process is discussed in Chapter 14 and illustrated in Fig. 14.13. The systems flowchart of Fig. 15.8 illustrates the computer processing of file changes and employee time card data to update the payroll master file and to prepare employee checks and earnings statements, the payroll register, and the summary payroll journal entry. The data preparation process generates batch totals and punched cards sorted into sequence by employee number. The payroll register generated by the file update program is on magnetic tape, and must be processed again to prepare a printed payroll register.

Some of the internal controls described for the manual payroll processing system are replaced in the computerized system by new sets of controls. For example, such batch totals as record counts of the number of employee time records and the number of file changes of each type, as well as hash totals of employee numbers and hours worked, should be prepared from source documents and compared to those accumulated during processing. Batch totals from the payroll master file itself, including the number of employees and a hash total of employee wage rates, should also be accumulated during processing and printed out for comparison to personnel department records. The keypunching step should be controlled by keyverification and the use of check digit verification on employee numbers. Furthermore, a printout of file change cards might be prepared and sent to the personnel department for verification of the integrity of all file changes processed.

Other important areas of control with respect to computerized payroll processing include data security and input validation. Internal and external labels, the tape file protection ring, and the grandfather-father-son concept should all be used to secure the payroll master file tape. In addition, access to this tape should be limited to authorized employees at the time scheduled for payroll processing. Edit checks within the main payroll program should include a sequence check, validity check on employee number, field check and limit check on hours worked, and reasonableness tests on rate increases and other file changes affecting the payroll computations. The validity of the computations might also be tested by means of a limit check on gross pay and net pay. Any records which violate one or more of these edit checks should be printed on the error list for subsequent follow-up and resubmission by someone independent of programming and operations.

The use of disk storage for the payroll master file rather than magnetic tape offers some advantages and some disadvantages. Among the possible advantages is the possibility that online data entry may be more economical and reliable than keypunching. In addition, some amount of retrieval capability with respect to payroll data may be desirable in some cases. However, tape is much cheaper for the large volumes of data typically contained on the payroll master. Therefore, the appropriateness of disk files for this purpose depends entirely upon the needs and characteristics of each particular organization.

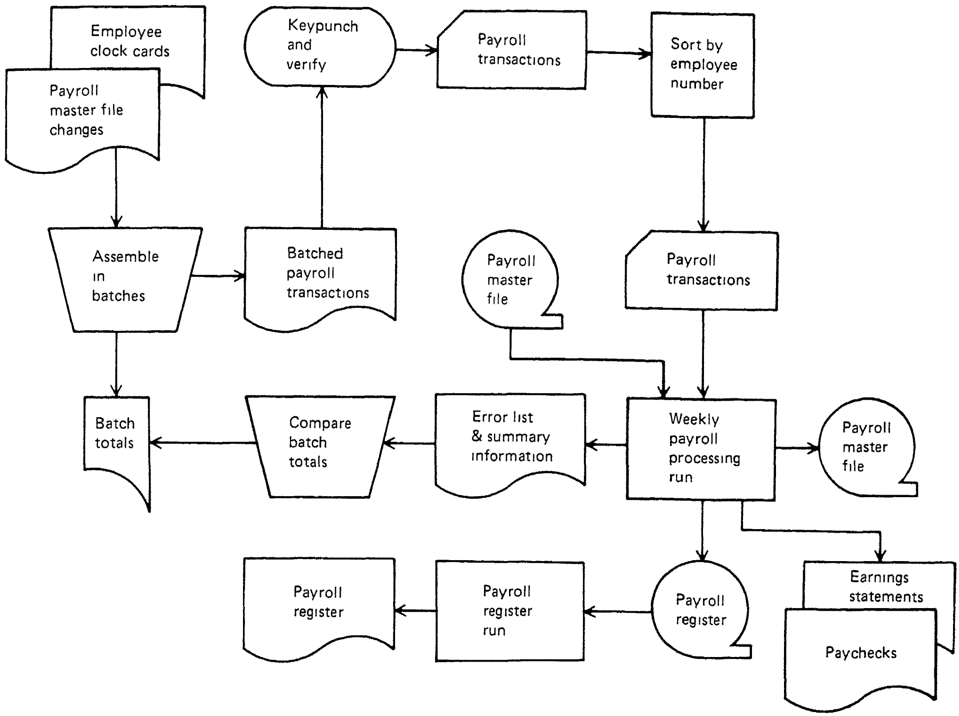


Fig. 15.8 Systems flow in computerized batch processing of payrolls.

REAL-TIME SYSTEMS FOR PERSONNEL MANAGEMENT

The use of real-time systems for payroll processing is very uncommon because there is almost no need for immediate access to payroll data. The processing of payroll transactions occurs on a regular cycle, once each week or month, and all such transactions are processed together. This makes the payroll application ideally suited for batch processing. However, as described in Chapter 14, the processing of job time and job cost data on a real-time basis as part of a real-time production order processing system is fairly common.

With respect to personnel management in general, the use of real-time systems offers significant advantages in some cases. Such cases involve organizations in which employee skills are an extremely important resource, and decisions involving the selection and assignment of the human resource are frequently made. One example would be large organizations of professional people, such as management consultants, engineers, or lawyers, which sell the services of their employees for a fee, and which often must search for an employee whose specialized qualifications best meet the requirements of a client. Other

examples include large placement services or employment agencies and military organizations. Large multidivisional corporations may also be interested in applying this approach to their top managerial and staff personnel.

A real-time personnel management system of this type would center around a personnel data base maintained on direct access storage. The data base would be indexed according to classifications of skills, experience, and other qualifications possessed by employees. A software system would be designed to facilitate searching the data base for the names of employees possessing certain desired combinations of characteristics. For example, an employee may be sought who possesses an educational background in engineering and management, experience in industrial engineering, and the ability to speak a foreign language. If such an employee existed, his name could be retrieved by the system in a matter of seconds or minutes, and his qualifications listed or displayed for review by management. By means of the index of skills, the personnel data base becomes a skills inventory file.

REVIEW QUESTIONS

1. In very general terms, what is personnel management and what type of information is processed by an information system for personnel management?
2. Describe or illustrate an example of a typical personnel organization structure. Describe the responsibilities of each separate personnel function within the organization.
3. Describe the information requirements of the top personnel executive in an organization.
4. Describe the personnel management responsibilities and related information requirements of the typical departmental supervisor within an organization.
5. Describe the nature of the personnel information generated by:
   a) the accounting information system,
   b) the personnel department,
   c) other sources of information within the business organization, and
   d) sources external to the business organization.
6. What input data is required for processing the payrolls of
   a) factory employees,
   b) salaried employees, and
   c) salesmen paid on a commission basis.
7. Identify several examples of nonroutine file maintenance transactions involving the payroll master file.
8. What is human resource accounting and how is it different from conventional accounting? Illustrate by means of sample journal entries.

9. What are the accounting journal entries which summarize the activities involved in payroll processing?
10. Describe in detail the data content of a payroll master file.
11. What departments in a manufacturing company might be involved in the manual processing of payrolls? What documents might be processed and what data would each contain? Where would each originate, and where and for what purposes would it be distributed?
12. What is a payroll register? a deduction register?
13. Describe several control procedures which might be used in a manual system for payroll processing.
14. How is organizational independence achieved with respect to payroll processing?
15. Explain some of the control procedures in payroll processing which are commonly performed by internal auditing personnel.
16. What is a payroll board and how might it be used?
17. Describe briefly how a bookkeeping machine might be applied to payroll processing.
18. Describe the similarities and differences in processing of payrolls in a typical business organization using a computer rather than a manual data processing system. Emphasize documents, departments, and reports involved in the process.
19. What internal controls might be used in computerized payroll processing?
20. In what types of situations might the use of disk storage for the payroll master file be appropriate?
21. Why is it uncommon for real-time systems to be applied to payroll processing?
22. What type of organization would utilize a real-time system for personnel management? Explain how such a system would be useful.

DISCUSSION QUESTIONS

23. Do some research to discover how financial accounting theorists define the term "asset." Are human resources considered as assets under this definition? Is it possible to record human resources as assets under generally accepted accounting principles? Should it be possible to do so? Discuss.
24. Do you expect that in the near future most large firms will utilize a real-time personnel management system? Discuss.
25. Does a good departmental supervisor really need quantitative information, such as measures of employee productivity, to adequately perform his personnel management function? Discuss.

PROBLEMS AND CASES

26. The Future Corporation is a small manufacturing concern in Aggie, Texas. It maintains one plant and employs 50 workers in its operations. The employees are paid weekly. The department foremen supply the payroll clerk with signed time sheets. The clerk compares the time sheets with the time cards and prepares the checks. The checks are then given in sealed envelopes to the foremen, who in turn give them to the respective employees. Comment on the internal control in the company's payroll system.

27. You are engaged in auditing the financial statements of Henry Brown, a large independent contractor. All employees are paid in cash because Mr. Brown believes this arrangement reduces clerical expenses and is preferred by his employees.

    During the audit you find in the petty cash fund approximately $200 of which $185 is stated to be unclaimed wages. Further investigation reveals that Mr. Brown has installed the procedure of putting any unclaimed wages in the petty cash fund so that the cash can be used for disbursements. When the claimant to the wages appears, he is paid from the petty cash fund. Mr. Brown contends that this procedure reduces the number of checks drawn to replenish the petty cash fund and centers the responsibility for all cash on hand in one person inasmuch as the petty cash custodian distributes the pay envelopes.

    a) Does Mr. Brown's system provide proper internal control of unclaimed wages? Explain fully.
    b) Because Mr. Brown insists on paying salaries in cash, what procedures would you recommend to provide better internal control over unclaimed wages?[3]

28. What controls in a manual system for processing factory payrolls are designed to provide the best protection against the following errors or manipulations?

    a) The carrying of names of former employees on the payroll after their termination in order to receive and cash their paychecks.
    b) Incorrect recording of hours worked on a job.
    c) A dishonest payroll employee overstating the pay rate or hours worked of his friends in order that their paychecks are higher than they should be.
    d) A factory employee punches his friend's clock card in at 1:00 and out at 5:00 while his friend spends the afternoon playing golf.
    e) An arithmetic error in calculation of gross pay for a factory employee.
    f) Incorrect calculation of Federal Income Tax deduction such that gross pay does not equal the sum of all deductions plus net pay.

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[3]Question 3, Auditing Section, American Institute of Certified Public Accountants Examination, November 1961. Copyright, © 1961 by the American Institute of Certified Public Accountants and reprinted with permission.

g) The cashier pocketing and cashing paychecks of terminated employees which are unclaimed.
h) An arithmetic error in the calculation of labor costs allocated to jobs in process.

29. The Witt Company is engaged in manufacturing. Certain features of its operating methods are described below.

    You are to consider the procedure for the activities described and point out the existing deficiencies, if any, in internal control, including an explanation of the errors or manipulations which might occur in view of each weakness and your recommendations as to changes in procedures which could be made to correct the weakness.

    Time cards of employees are sent to a tabulating machine department which prepares punched cards for use in the preparation of payrolls, payroll checks, and labor cost distribution records. The payroll checks are compared with the payrolls and signed by an official of the company who returns them to the supervisor of the tabulating department for distribution to employees.[4]

30. The Kowal Manufacturing Company employs about 50 production workers and has the following payroll procedures.

    The factory foreman interviews applicants and on the basis of the interview either hires or rejects the applicants. When the applicant is hired he prepares a W-4 form (Employee's Withholding Exemption Certificate) and gives it to the foreman. The foreman writes the hourly rate of pay for the new employee in the corner of the W-4 form and then gives the form to a payroll clerk as notice that the worker has been employed. The foreman verbally advises the payroll department of rate adjustments.

    A supply of blank time cards is kept in a box near the entrance to the factory. Each worker takes a time card on Monday morning, fills in his name, and notes in pencil on the time card his daily arrival and departure times. At the end of the week the workers drop the time cards in a box near the door to the factory.

    The completed time cards are taken from the box on Monday morning by a payroll clerk. Two payroll clerks divide the cards alphabetically between them, one taking the A to L section of the payroll and the other taking the M to Z section. Each clerk is fully responsible for her section of the payroll. She computes the gross pay, deductions, and net pay, posts the details to the employee's earnings records, and prepares and numbers the payroll checks. Employees are automatically removed from the payroll when they fail to turn in a time card.

    The payroll checks are manually signed by the chief accountant and given to the foreman. The foreman distributes the checks to the workers

[4]Adapted from Question 8, Auditing Section, American Institute of Certified Public Accountants Examination, May 1951. Copyright © 1951 by the American Institute of Certified Public Accountants and reprinted with permission.

in the factory and arranges for the delivery of the checks to the workers who are absent. The payroll bank account is reconciled by the chief accountant who also prepares the various quarterly and annual payroll tax reports.

List your suggestions for improving the Kowal Manufacturing Company's system of internal control for the factory hiring practices and payroll procedures.[5]

31. The Karras Corporation is a large multidivisional enterprise. One of its divisions is located in Farmbelt, Iowa. In the spring of 1971 the personnel manager of the Farmbelt Division and his assistant went on a recruiting trip to several midwest business schools. Four graduating business school students were hired as management trainees. The total cost of the recruiting trip was $1,000.

    In the summer of 1971 the four management trainees were sent to Chicago for a corporate training program. Travel and lodging for the trip cost $600. Corporate headquarters charged the division $400 per trainee as the cost of the training session. Upon completion of the training program, each of the four new employees was assigned to an assistant manager position at the Farmbelt Division.

    In late 1971 Karras Corporation's top management decided to institute an extreme cost-cutting campaign for the year 1972. The Manager of the Farmbelt Division wondered whether he should retain the services of his four new assistant managers. He had planned to assign them to permanent management positions in July of 1972. If he released them, their salaries of $4,200 each for the first six months of 1972 could be saved. However, four new employees would eventually have to be recruited, trained, and allowed to gain some experience for the four management positions which would be open in July of 1972.

    a) Show by means of journal entries how the recruiting, training, and travel expenditures would be treated using conventional accounting principles.
    b) Show by means of journal entries how the recruiting, training, and travel expenditures would be treated using human resource accounting.
    c) If the four new assistant managers are released, what journal entry would be made in (1) a conventional accounting system, (2) a human resource accounting system.
    d) Would the conventional or human resource accounting system provide more meaningful information in this case for purposes of deciding whether to release or retain the four assistant managers? Explain.

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[5]Question 2, Auditing Section, American Institute of Certified Public Accountants Examination, May 1964. Copyright © 1964 by the American Institute of Certified Public Accountants and reprinted with permission.

32. Describe internal controls in a computerized system for payroll processing which are designed to provide the best protection against the following errors or manipulations.

    a) Overstatement of an employee's wage rate on the payroll master file.
    b) Placing the name of a fictitious employee on the payroll master file.
    c) Entry of 80 as the value of hours worked on a particular date for an employee who only worked 8 hours on that date.
    d) A computer operator entering a payroll transaction card to increase his own salary by 50%.
    e) A programmer obtaining the payroll master file and entering an increase in his own salary.
    f) Accidental erasure of a portion of the payroll master file tape by a computer operator making an error correction entry over the console.
    g) Destruction of a large portion of the payroll master file when the disk pack containing the file was used as a scratch file for another application.

33. As a systems consultant of wide repute, you have been invited to the executive offices of Consolidated Flypaper Corporation for an interview with the controller. The controller has indicated to you that he is concerned about the operation of the company's payroll processing system. Recent expansion of the company has placed a strain upon the system such that frequent overtime is necessary for regular processing to be completed.

    The payroll and cost distribution sections of the company perform their functions almost entirely manually, with the only mechanical aids being typewriters and hand calculators. In addition to the problem of frequent overtime being necessary, the controller has indicated some additional problems with the system, including a lack of useful management reports which could be produced by the system and possible weaknesses in internal controls within the system. The controller has indicated that he is considering three possible alternatives, including hiring additional employees in the payroll and cost distribution sections, acquiring a multiple-purpose accounting machine for use in those sections, or installing punched card equipment.

    The controller has assured you that the president and other top executives of Consolidated Flypaper agree with the necessity of a systems study conducted by a qualified outsider. You have been introduced to the assistant controller, who performs internal auditing functions, and told that he is available to assist you full time if necessary.

    You have agreed to accept this assignment, and have decided to send two of your assistants to complete the initial work while you finish another project. You wish for your assistants to complete a preliminary evaluation of possible alternatives, which you will use in making a final decision and preparing recommendations.

Required:

Prepare a schedule of activities to guide your assistants in performing their assignment. Be fairly explicit regarding the kind of information they might expect to find in a payroll processing system, how they should go about collecting it, and how to proceed in analyzing it. Please note that you are not being asked to give a solution to the problem, but only to describe, with reference to the particular situation, how a systems analyst would proceed with the initial phases of a systems investigation.

34. The Sharpesville Insurance Company utilizes a computer based system with disk file storage. Among the files which it maintains on disk are a salesman's payroll master sequenced by salesman number, and a policyholder's master sequenced by policy number.

Each salesman's monthly gross pay is equal to $300 plus commission. Each salesman's commission is calculated as 5% of all premiums collected during the first year of the policy from policyholders who purchased from the salesman, and 1% of all premiums collected during the next four years from those policyholders.

Each day the policyholder's master file is updated for new policies sold and premium payments received on outstanding policies. All premium payments are collected on a monthly basis. At the end of each month, the policyholder's master and salesman's payroll master are processed to generate salesman's paychecks. Each salesman's paycheck and payroll statement data are punched onto cards, which are subsequently processed on an interpreter and distributed to salesmen. Other outputs from this run include three printed reports: a payroll register, a listing of all policyholders who did not pay their premium for the month, and a summary report.

a) What data must be contained in each policyholder master record in order for that file to be used as described above in generating salesman's payroll data? (Do not mention policyholder master data which is not used in generating salesmen's payroll data.)
b) Prepare a systems flowchart of the monthly payroll processing run described above.
c) Assume that the processing illustrated in part (b) is done sequentially. What operation must then be performed on the policyholder's master file prior to the run?
d) What accounting journal entry would be accumulated in the run and printed out as part of the summary information? (Show accounts debited and accounts credited.)
e) Prepare a macroflowchart of the monthly payroll processing program. The flowchart should include: (1) separate input and output symbols for each file processed in the run; (2) decision symbols necessary to accomplish sequential processing, to determine whether or not to include each policyholder on the listing of policyholders behind on premium payments, and to determine the appropriate rate to be used in calculat-

ing the salesman's commission; and (3) a single processing step representing calculation of net pay, and all processing steps necessary to accumulate gross pay.

35. The Mayberry Corporation has acquired a tape-oriented computer system which will perform several clerical functions previously done manually. You have been called upon to design a computerized system for one of these functions – the processing of factory payrolls.

The computerized system will include a medium-sized central processor, several tape drive units, one card reader, one printer, and several keypunch and verifier units. No other hardware is available for use in payroll processing.

You have investigated the existing manual system and have discovered that it operates in the following manner. Employee clock cards are maintained in the timekeeping department, each of which contains an employee number and name and the time clocked in and out of work for each day of the week by the employee. All of these cards are sent to the payroll department at the end of each week. The payroll department also receives data on new employees, employee terminations, changes in address or deductions, and other nonroutine payroll transactions from the personnel department. The payroll clerks perform all steps necessary to prepare employee paychecks and earnings statements, prepare a payroll register (weekly listing of payroll data for each employee), and maintain payroll records as required for producing quarterly and annual summary reports on employee earnings and withholdings as required by the government.

Your discussions with various system users have produced one major finding. Factory foremen are unanimous in requesting a weekly report on employee tardiness and absenteeism, which would include such data as the average number of hours lost through lateness and absenteeism per week during the current year for each employee in the foreman's department.

Required:

a) Describe the data content of any master file or files necessary to perform the payroll processing by computer.
b) Prepare a systems flowchart representing a preliminary design of the computerized payroll processing system. Show all operations required, commencing with receipt of source documents and terminating with production of all necessary system outputs. For simplicity, do not include in this preliminary design any internal control operations.

36. The Darwin Department Store pays all of its employees on a salaried basis. Payroll processing is done once monthly by computer. The payroll master file is maintained on a disk file. The only transaction inputs to the run are file changes on punched cards. Outputs include: (1) a report listing error transactions and summary information, (2) employee checks and earnings statements on punched cards, and (3) a payroll register on magnetic tape.

The processing is done sequentially. The check and earnings statement cards are subsequently processed to print the appropriate data on the face of the cards. The payroll register tape is also processed by a utility routine to prepare a printed payroll register printout.

Required:

a) Explain what is meant by "file changes" in the above description. Give four examples which you would expect to find in this process.
b) Prepare a systems flowchart of the computer processes described above.
c) List the components of the hardware configuration necessary to accomplish all phases of the processing described in the case subsequent to keypunching. Be sure to allow for necessary offline operations.
d) Describe a comprehensive set of control policies and procedures for this payroll processing application. For each policy or procedure, indicate its objective and exactly how it would operate. Be sure to relate each policy or procedure specifically to the payroll processing system described above.

Chapter 16

Accounting Information Systems for Financial Management

Financial management involves decisions relating to sources of financing for, and uses of financial resources within, an organization. Financial information is any information concerning the flow of dollars through the organization. Virtually all activities and decisions within an organization are reflected in financial information. The financial management function, and systems for providing financial information, are thus vital to all business organizations, as well as to most other types of organizations. This chapter discusses the nature of the financial management function, and of systems for generating financial information, within the typical business organization.

THE FINANCIAL MANAGEMENT FUNCTION

The financial management function encompasses both the role of treasurership, or administration of the finance function, and controllership, or administration of the accounting function. In many business organizations, the treasurership and controllership functions are combined organizationally under the authority of an Executive Vice President for Finance. An example of an organization structure of this type is illustrated in Fig. 16.1. The controllership function encompasses the collection and processing of transaction data and the reporting and interpretation of financial information. To the modern business organization, attempting to generate an economic profit from scarce resources in a competitive environment, the availability of relevant, timely, and reliable financial information is essential. Because of the importance of the financial reporting and interpretation activity, the controller has become an important participant in managerial decision making at the top level.

The controllership function and its subsidiary functions – budgeting, tax planning, internal auditing, and general accounting, are discussed in Chapter 2 and elsewhere throughout this book. Therefore, the remainder of this section concentrates upon the functions of the top financial executive, the treasurer, and the various staff functions reporting to the treasurer. Each of these is discussed here in turn.

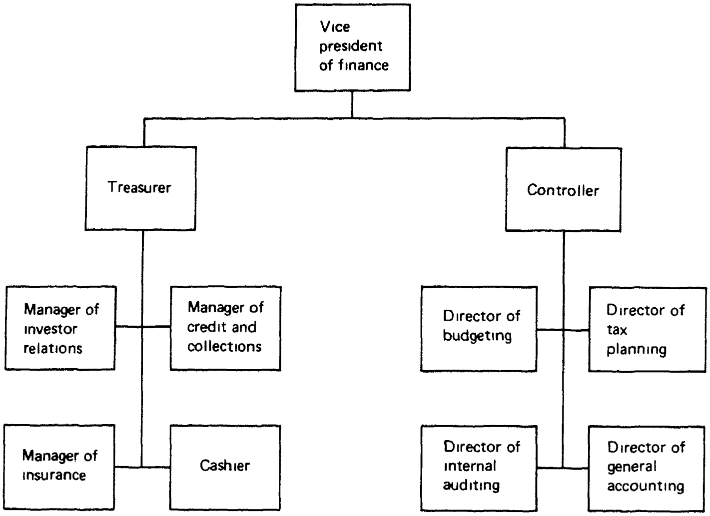

Fig. 16.1 Organization structure for financial management.

The Top Financial Executive

The top financial executive, often having the title of financial vice president, is responsible both for administration of the functions under his authority, and for making decisions and recommendations involving the most important aspects of the finance function. Into the latter category fall decisions concerning long-term financing, dividend policy, capital budgeting, short-term management of cash flows, and allocation of resources within the enterprise.

Decisions concerning long-term financing are generally made very infrequently in most business organizations, perhaps only once every few years. However, each major decision in this area will have a significant impact upon the firm's success and growth over an extended period of time. The two most crucial aspects of the long-term financing decision are timing and sources. The timing aspect involves determining the point in time at which entry into the capital markets can be achieved on terms most favorable to the firm. Selecting the sources of long-term financing involves choices among such alternatives as issuing bonds, common stock, or preferred stock. Dividend policy is also closely related to long-term financing, since another source of long-term funds consists of retained earnings which are not paid out as dividends.

Much of the information required for decisions on long-term financing is external information concerning, for example, the state of the economy and its impact on stock and bond prices, interest rates, and the capital markets generally. Internally generated information useful to decision making in this area includes long-term past and future information regarding the firm's financial position and earnings performance. The basic financial statements generated by the

accounting function – balance sheet, income statement, etc. – provide a perspective on past trends and present conditions in this regard. Major plans developed by top executives, and financial projections generated on the basis of such plans, are also an important source of information input.

Planning and control of capital expenditures is another area of decision making in which the top financial executive is deeply involved. The planning of capital expenditures involves determining the total size of the capital expenditures budget for the firm each year or quarter, and choosing among alternative fixed asset purchases. The control of capital expenditures deals with establishing policies for granting approval of expenditure requests and following up on the execution of the expenditure and the installation of the asset.

The information required for capital expenditure planning consists primarily of estimates of cash inflows and outflows and of risk factors associated with alternative fixed asset purchases. The discounting technique should be applied to cash flow estimates to derive a net present value for each alternative investment.[1] The availability of funds for capital expenditures may be estimated on the basis of sales forecasts and earnings projections. Information for control of capital expenditures begins with the formal request for authorization of the expenditure, which indicates the costs associated with the purchase, the expected benefits, and the projected revenues or cost savings. When the asset is purchased and received, a record of all vital data relating to the asset should be prepared and maintained for as long as the asset is owned and used. Other control information may be generated from follow-up studies which evaluate the accuracy of the original cost and revenue estimates.

Planning and control of operating expenditures is another area of major concern to the top financial executive. This involves the preparation of annual operating budgets for departments and divisions within the organization. It also includes establishing systems of control reporting which generate comparisons of actual performance of each department or division with the operating budget. Finally, it involves the interpretation of reported operating performance to provide a basis for managerial decisions and actions.

The Treasurer

The treasurership function is primarily concerned with the management of short-term cash flows and with policy making and administration with respect to various staff functions under his authority. Cash management involves decisions relating to the investment of cash balances in excess of short-term cash requirements and decisions on timing and sources of short-term cash borrowing. Alternatives for short-term cash investment include United States Treasury bills, bank certificates of deposit, and commercial paper. Alternative sources of short-term borrowing include trade credit, commercial bank unsecured credit, and secured loans using inventories or accounts receivable as collateral.

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[1]For an extensive treatment of capital budgeting and cash flow discounting, see Harold Bierman and Seymour Smidt, *The Capital Budgeting Decision,* 3rd edition (New York: The Macmillan Company, 1971).

The information requirements of short term-cash management involve both external and internal information. Decisions on investment of idle cash require information of the nature, yield, and maturity dates of various alternative investments. Decisions on short-term borrowing utilize information relating to sources of supply. The timing decision primarily depends on internal information concerning when excess cash balances will be available, or when short-term borrowing will be required. Short-term cash budgets which project weekly or monthly cash flows for the immediate future are one source of such information. These budgets may be supplemented by revenue projections generated from accounts receivable data, and by cash outflow projections generated from accounts payable and purchase commitments data.

Manager of Investor Relations

The manager of investor relations has the responsibility of developing and maintaining a satisfactory market for the firm's securities. This entails communications with stockholders; with security analysts, who advise investors; with stock exchanges, through which securities are traded; with investment bankers, through whom new securities are issued; and with the Securities and Exchange Commission, which regulates the securities markets. The information requirements of this position are primarily external. The stockholder record keeping system provides some information of use to the investor relations manager, such as reports on the holdings and dealings of the company's largest shareholders. In addition, much company information is funneled through the investor relations manager and reported to stockholders, security analysts, and others interested in the company's activities.

Manager of Credit and Collections

The manager of credit and collections has the responsibility of developing and administering policies relating to the granting of credit and collection of accounts. Credit granting policies, credit limits, and collection procedures must be tight enough to avoid tying up funds in accounts receivable which could be profitably invested elsewhere. On the other hand, such policies and procedures must be loose enough to avoid the loss of sales and customers. The manager of credit and collections must find the optimum point of trade-off between these two objectives.

Some of the information requirements of the credit and collections function are external. For example, information on the credit-worthiness of new customers is required to decide whether and to what limit to extend credit to them. Primary external sources of credit information include Dun and Bradstreet, which provides credit reports and ratings on business firms, and local credit bureaus, which provide credit reports on individuals. Much internal information should also be available to assist in credit decisions. Records of the payment history of a customer are useful to making decisions on whether

to extend further credit. Records of current past due balances are also relevant to the credit granting decision, and necessary to the decision of whether to initiate special collection procedures. Reports analyzing customer accounts written off as uncollectable are constructive in the establishment of credit granting policies.

Manager of Insurance

The manager of insurance is responsible for identifying and evaluating potential losses to the firm which are insurable, selecting the appropriate mix of insurance coverage and other methods for dealing with the potential losses, obtaining insurance coverage on terms favorable to the firm, and administering the firm's various insurance contracts. This responsibility requires the use of both external and internal information in decision making. External information requirements include knowledge of the characteristics and costs of various types of available insurance coverage. Examples of internal information requirements are measures of: potential loss from physical damage to assets, disability or death of key employees, criminal action, and fraud or negligence on the part of employees. In the case of physical damage to assets, accounting records provide some useful information. However, in the case of the other types of losses mentioned, accurate measures of size and likelihood of potential loss may be hard to develop from available information. For administration of insurance programs, the insurance manager must receive information concerning payment of premiums, execution of new insurance contracts in accordance with established policies, maintenance and funding of reserves for self-insurance, and reporting and collection of claims.

Cashier

The function of cashier is primarily administrative rather than being a policy-setting or decision-making function. The cashier is responsible for endorsing, depositing, and maintaining a record of cash receipts, and for reviewing disbursement authorizations, signing and distributing checks, and maintaining a record of cash disbursements. This function also encompasses the maintenance of banking arrangements for the organization.

THE FINANCIAL INFORMATION SYSTEM

This section reviews the basic accounting transactions reflecting the processing of information for financial management, describes the data content and organization of the primary master files maintained as part of such processing, and discusses and illustrates examples of manual and computer based information systems for financial management. The systems illustrated are not those of any real organization, but are intended to be representative of financial information systems in general.

The Accounting Transactions

Numerous accounting transactions summarize the processing of data from which accounting information for financial management is generated. The most significant of these are reviewed here.

Cash receipts and disbursements. With respect to cash receipts, the primary accounting journal entry is as follows:

Cash	XXX	
Accounts Receivable		XXX

This summary entry is typically made daily for the complete batch of cash receipts processed during the day. Other miscellaneous accounts which reflect less regular sources of cash receipts include notes receivable, sales of fixed assets, and miscellaneous income from dividends, interest, or rentals.

The primary cash disbursement transactions are reflected by the following journal entry:

Accounts Payable	XXX	
Cash		XXX

The entry is also generally made each day to summarize the preparation and distribution of a batch of checks. Credits to accounts payable originate from purchases of inventory and fixed assets, and from the incurrence of costs and expenses.

Another cash disbursement transaction reflecting a high volume of individual transactions appears thus:

Wages and Salaries Payable	XXX	
Cash		XXX

The liability account is originated weekly or monthly as payrolls are processed, and represents the difference between gross pay and all deductions. The entry itself reflects the distribution of paychecks to employees.

A third cash disbursement entry which represents the most regularly recurring transaction with stockholders is as follows:

Dividends Payable	XXX	
Cash		XXX

The liability account itself is originated by debiting the Retained Earnings account. This transaction is generally executed quarterly and the entry summarizes the distribution of a batch of dividend checks to all stockholders. Most corporations utilize the services of a bank as transfer agent, which involves administering records of share transfers among stockholders. Many firms also have their transfer agent process dividend payments as well. Systems for administering capital stock records are not discussed further in this chapter.

Cost and expense distribution. Various accounting processes culminate in the recording of costs and expenses. A composite entry reflecting several of the most significant of these processes appears below:

Manufacturing Overhead	XXX	
Selling Expense	XXX	
General and Administrative Expense	XXX	
Accounts Payable		XXX
Payroll		XXX
Accumulated Depreciation		XXX
Supplies		XXX
Accrued Expenses Payable		XXX
Allowance for Bad Debts		XXX

The accounts debited in the above composite entry are control accounts, each of which encompasses a large number of subsidiary cost and expense accounts. Examples of the subsidiary accounts include wages and salaries expense, depreciation, insurance, taxes, utilities, advertising, supplies, travel, and bad debts. These debits arise from several processes. Perhaps the primary source is the debit distribution generated from the daily preparation of disbursement vouchers, which establish and authorize payment of accounts payable. The debit distribution summarizes the accounts to which the total amount payable is apportioned. The payroll entry is made as payrolls are processed weekly or monthly. The debit to supplies expense and credit to supplies inventory is made as supplies requisitions are processed, but is subject to adjustment as periodic inventories of supplies are taken. The depreciation and accrual portions of the entry, including the estimate of bad debts expense, are generally made at the end of each month.

Fixed assets. The recording of fixed asset acquisitions is reflected by the following journal entry:

Fixed Assets	XXX	
Accounts Payable		XXX

If the asset is a very large purchase, the credit portion of the entry may be partly to a long-term liability account. Very small asset purchases may simply be expensed for the sake of convenience. This entry generally arises as part of the debit distribution of accounts payable, as described above. The volume of such transactions is usually minimal in relation to other debits arising from accounts payable processing.

Financial statement preparation. Standard practice calls for most firms to prepare balance sheets and income statements monthly. The three special types of journal entries made in conjunction with financial statement preparation are: accrual entries, adjusting entries, and closing entries. Accrual entries record the accrual of unpaid expenses or the expiration of prepaid

expenses as of the closing date of the statements. Adjusting entries include any special entries made for the purpose of correcting account balances, such as an adjustment of the inventory accounts in accordance with a physical inventory, or the elimination of profits and account balances arising from intercompany transactions. Closing entries reflect the closing of all revenue and expense account balances and the transfer of the net credit or debit (net income or loss) from those accounts to the retained earnings account.

The Master Files

The master files most directly associated with the processing of accounting data to generate financial information are actually subsidiary ledgers to the general ledger. The term "ledger," used in an accounting context to mean master file, is a carryover from manual systems in which such files were maintained in bound ledger books. The most significant subsidiary ledgers are: accounts receivable; inventory, including raw materials, work-in-process, and finished goods; fixed assets; accounts payable; manufacturing overhead; selling expense; and general and administrative expense. Other master files important to the financial information system are the general ledger itself and the master budget.

The basic format of all ledger accounts is identical. Each contains a control field, the account balance as of the beginning of the current period, an itemization of all transactions affecting the account during the current period, and the current account balance. In addition, each type of ledger account contains other data items unique to it, such as account titles, names, or descriptions.

The sum of the current dollar balances of all accounts within a subsidiary ledger should equal the balance of the control account corresponding to that subsidiary ledger. The control account, in turn, is part of the general ledger, which also includes accounts for which no subsidiary ledger exists, such as cash, the various equity accounts, and sales. The equality of each control account balance with the sum of all balances in the corresponding subsidiary ledger is maintained by the posting of summary journal entries to the general ledger each time a batch of transactions is posted to a subsidiary ledger. This process is illustrated several times in previous chapters.

The control field for all accounting ledgers is the account number, and the set of account numbers for the general ledger and subsidiary ledgers comprise the chart of accounts. The code structure of account numbers may be very simple or very sophisticated. At a minimum, the code must contain digit positions identifying the account itself — one set for the general ledger account and a second set for the subsidiary ledger account. In addition, the code may provide digit positions for identification of the department responsible for the funds represented by the account (see Chapter 2), the project or job to which the balance represented by the account is charged, and the division or plant in a multiplant company.

The data content and organization of accounts receivable, accounts payable, and the various inventory ledgers are described in previous chapters. An example of a fixed asset ledger record is illustrated in Fig. 16.2. The basic transaction input to the fixed asset ledger consists of records of new asset purchases and of the sale or scrapping of existing assets. This ledger is used as a basic reference for general accounting, capital budgeting, insurance administration, and tax planning. Basic outputs generated from the fixed asset ledger are depreciation schedules, in summary form and perhaps analyzed in detail by department, division or project.

The data content and organization of the manufacturing overhead ledger, the selling expense ledger, and the general and administrative expense ledger correspond almost directly to the basic format of all ledger accounts as described above. The beginning balance of all accounts in these ledgers is always zero, since they are closed to the profit and loss summary at the end of each period. Little descriptive information other than an account title is included in these account records. Each transaction subrecord within each subsidiary account contains the transaction date, amount, and disbursement voucher or other source document reference number. The only difference between these ledgers lies in the type of accounts included in each. Constituting the manufacturing overhead ledger are such accounts as inspection, supervision, maintenance and other indirect labor, small tools, factory utilities, depreciation on plant and factory equipment, and so forth. The selling expense ledger is comprised of accounts for salaries and commissions of salesmen, salaries of sales supervisors and clerical staff, shipping expenses, depreciation of selling facilities and equipment, supplies, postage, advertising, travel, etc. The general and administrative expense ledger includes accounts for executive and clerical salaries, depreciation and rental of office facilities and equipment, supplies, postage, travel, contributions, and income taxes.

The cost and expense ledgers are updated for accounting transactions arising from accounts payable debit distribution, payroll processing, and depreciation, accruals, and other end-of-period adjustments recorded on journal vouchers. The most important reports generated from this file are departmental performance reports comparing the actual expenses incurred in each department, obtained from the ledger, with budgeted expenses, and perhaps also with expenses incurred for the same period in the previous year.

The data content and organization of the general ledger also corresponds to the universal ledger format described above. Transaction inputs to the general ledger are posted from journal vouchers containing either summary entries from batch processing of daily and weekly transactions or end-of-period entries. The most important outputs from the general ledger are the financial statements of the firm and of its subsidiaries and divisions. Forming a part of such statements may be comparisons of current year-to-date results and position with budgeted and/or prior year amounts.

KRAUSZ MFG. CO. **PLANT AND EQUIPMENT HISTORY LEDGER** SYRACUSE, N.Y.

ITEM NO. 4462 ACCOUNT NO 5 CLASS 2 TYPE 125

	DESCRIPTION	MANUFACTURER	SERIAL NO.
	DRILL PRESS MODEL 2	NATIONAL CO.	A 76289
A	SAFETY DEVICE	AJAX MFG. CO.	36114
B			
C			

		A	B	C
DATE ACQUIRED	4/60	4/60		
REFERENCE NO.	333	37001		
ORIGINAL COST	3,405.00	88.25		
TRANSPORTATION	120.00			
INSTALLATION LABOR	32.00	4.00		
INSTALLATION MATERIAL	15.00	.75		
INSTALLATION OTHER	28.00	3.00		
TOTAL COST	3,600.00	96.00		
ESTIMATED SALVAGE	192.00			
DEPRECIABLE AMOUNT	3,408.00	96.00		

DATE	REFERENCE NO.	PLANT	BLDG.	FLOOR	DEPT.
5/60		1	1	1	5

MOTORS

DATE	NUMBER	DESCRIPTION
5/60	15697	10HP AC 220V 60CY

Fig. 16.2 Fixed asset ledger record. (Reprinted by permission from *Plant and Equipment Accounting*. Copyright © 1971 by International Business Machines Corporation.)

Most modern organizations utilize budgeting in financial planning and control which requires the preparation of an annual budget each year for the forthcoming year. This budget is also a master file corresponding in structure to the general ledger. Account number is the control field, and the file contains a record for each control account in the general ledger as well as for each cost and expense subsidiary account. For each balance sheet account, the budget indicates the expected ending balance for each month in the year. For each income statement account, the budget indicates the amount of revenue and expense for each month of the year. Actual revenue and expense for each month of the previous year may also be included. If the firm uses a flexible budget, as most do, each cost and expense account in the master budget must show the fixed amount of the cost or expense per period, the variable rate of the cost or expense, and the base to which the variable rate is applied. For example, indirect labor for the assembly department might be budgeted at $1,000 per month (the fixed portion) plus ten cents per direct labor hour (the variable portion).[2]

The master budget is updated periodically to reflect current information with respect to budget estimates. Many reports for control purposes are generated as output of the master budget. Reports comparing actual and budgeted expenses by department and division are essential for performance evaluation and feedback to managers. Short-term cash flow budgets may also be generated from the master budget.

Manual Systems

Manual data processing systems for processing cash receipts and cash disbursements are described in this section and illustrated by means of document flowcharts. Brief descriptions of systems for maintaining the fixed asset ledger and the general ledger are also included. Emphasis is placed upon data flows and internal control provisions of these systems.

Cash Receipts. Figure 16.3 illustrates the process of receiving payments on account for a typical manufacturing company. It is assumed that the company receives most such payments by check through the mail. These are opened in the mail room, where a list of all receipts in a batch is prepared, perhaps in the form of an adding machine tape. All checks are sent to the cashier's department for endorsement and deposit in the bank. The batch total accumulated in the mail room is used by the cashier's department as a check on the accuracy of the deposit. On the basis of the deposit, the cashier's department prepares a journal voucher debiting cash and crediting accounts receivable. This is sent to the general ledger section.

Enclosed with each customer's payment should be a *remittance advice,* which indicates the invoices, statement, or other items for which the payment is made. If most of its customers are small companies or individuals, a company should request that the customer return one copy of the invoice or statement with his payment, and this then serves as a remittance advice. Remittance advices are separated from checks in the mail room and sent in a batch to accounts receivable, where they are posted to individual accounts. At the completion of the posting process, a new balance of accounts receivable is calculated, and the total change in accounts receivable is determined. This total change is then compared by the general ledger section to the amount of the journal voucher from the cashier's department. If the two amounts do not agree, an error has occurred which must be discovered and corrected.

The accounts receivable clerk should periodically check the status of all open customer accounts. Any accounts for which payment is significantly past due should be brought to the attention of the manager of credit and collections. This information might be reported in the form of an aging schedule of all past due accounts. On the basis of this feedback, the manager of credit and collections may decline to provide further credit to these customers, and may also initiate special collection procedures. In the event that account writeoffs become necessary, their initiation should occur in the credit department after all attempts to collect the account have proven unsuccessful. The

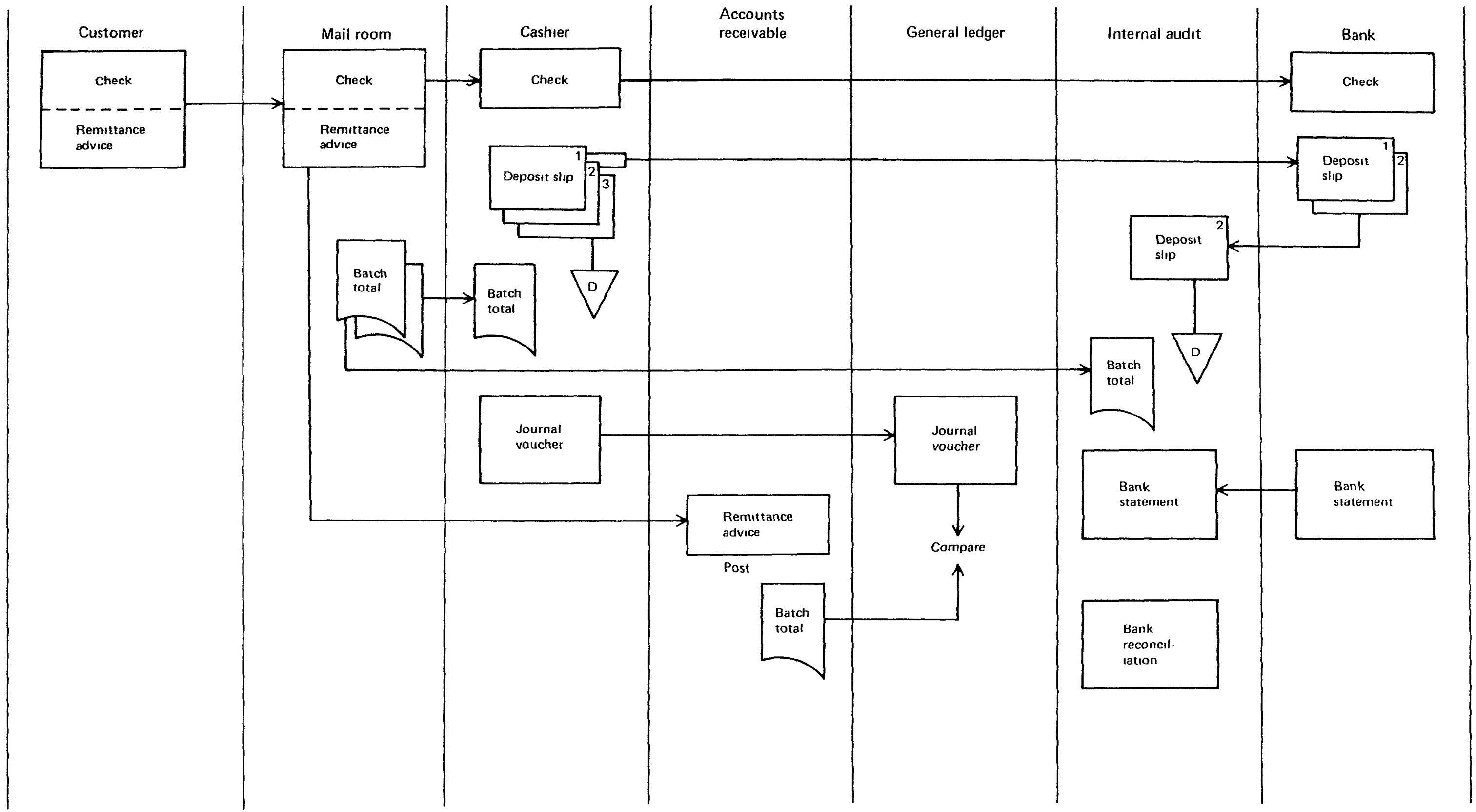

Fig. 16.3 Document flow in a manual system for processing cash receipts.

credit department would prepare a journal voucher recording the debit to allowance for bad debts and the credit to accounts receivable for posting by the general ledger clerk. A copy of the writeoff authorization would also be sent to the accounts receivable clerk for posting to the subsidiary ledger account.

The internal audit department plays an important role in the control of the cash receipts process. It receives a copy of the batch total of cash receipts from the mail room each day, and a copy of each deposit slip. At the end of each month it receives a bank statement, on the basis of which it prepares a bank reconciliation. Part of the work involved in preparing the bank reconciliation will be to compare each batch total with its corresponding deposit slip and bank statement entry. This check should reveal any errors or irregularities that occur after a proper batch total is accumulated in the mail room.

Organizational independence with respect to the cash receipts process is achieved by separation of the recording functions from the custodial function. Recording functions are performed by mail room personnel and by accounts receivable. The custodial function consists of the authority to endorse and deposit checks, which is the responsibility of the cashier. With respect to account writeoffs, separation of their authorization from the maintenance of the account records and the handling of cash receipts is essential. The independently performed functions of the internal auditor also impose a control check on the process. The batch total procedure and preparation of the bank reconciliation provide further control.

The establishment of procedures to control sales of merchandise for cash is a major concern of retail enterprises. The most critical point in the process from a control standpoint is the point of the transaction itself. Once the transaction is properly recorded, a firm basis for control has been established. Two factors are most useful in securing control at the point of the transaction itself. One is the use of cash registers, whose control features include: a display window in which the amount rung up for a sale is shown, provision for issuing a receipt for each sale to the appropriate customer, and a locked-in paper tape record of each transaction. The second critical control factor is close supervision of personnel.

Many organizations use a form of internal check to control the cash sales process subsequent to the recording of the sale. Sales slips are prepared at the point of sale, and at the end of each day are processed in a batch to update sales records. A batch total of cash sales is obtained from this process. Also at the end of each day, cash from each register is collected and cash register tapes are used as a basis for preparing a deposit slip and a journal voucher to record the debit to cash and the credit to sales. The totals obtained from these two processes are then reconciled, with adjustments made for credit sales, payments by check, sales returns, and like factors. If a discrepancy exists, steps can be taken to discover and correct the error.

Cash disbursements. A document flowchart of a manual system for processing cash disbursements is illustrated in Fig. 16.4. The accounts payable department

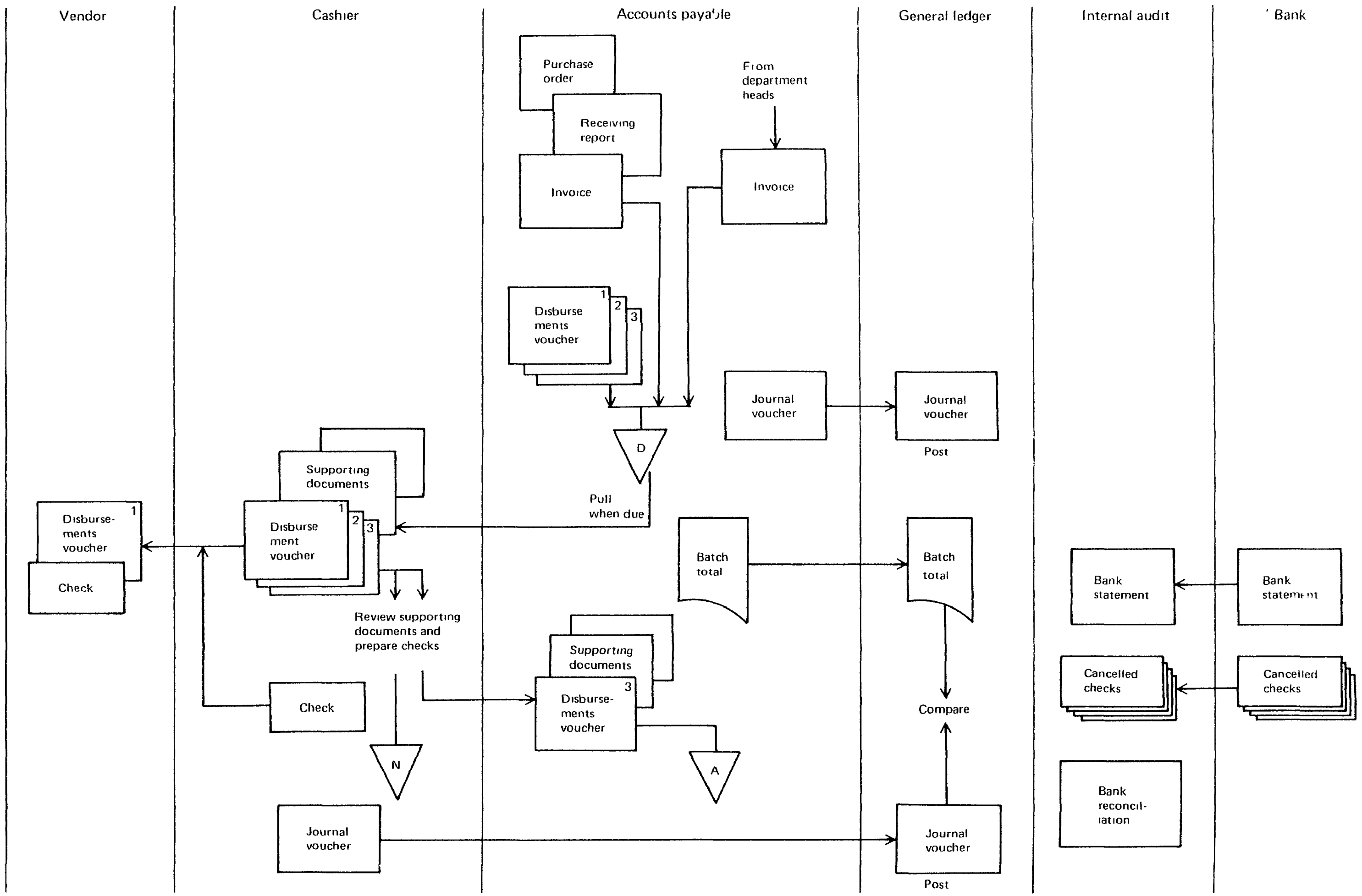

Fig. 16.4 Document flow in a manual system for processing cash disbursements.

maintains a file of invoices approved for payment by due date of the invoice. Approval of invoices for payment is made by the accounts payable department for inventory purchases on the basis of purchase orders and receiving reports. For costs and expenses and fixed asset purchases, payment authorization may be provided by the signature on the invoice of the department head to whose department the cost, expense, or asset is charged. For each invoice, or each set of invoices from one vendor, which has been approved for payment, a *disbursement voucher* is prepared. The disbursement voucher, illustrated in Fig. 16.5, is simply an authorization to pay a vendor for the invoices and amounts shown on the voucher.

Three copies of each disbursement voucher are prepared for each approved invoice and filed by due date together with all supporting documents. At the same time, the accounts payable department prepares the debit distribution; this details the accounts to which all debits arising from recognition of accounts payable are charged. After the processing of each day's batch of vouchers is completed, the accounts payable department prepares a journal voucher summarizing the debit distribution and indicating the total credit to accounts payable. The journal voucher is provided to the general ledger clerk for posting to the general ledger and the cost and expense subsidiary ledgers.

Each day the file of vouchers payable on that day is pulled. A batch total of the net amount to be remitted is prepared, and the disbursement vouchers and all supporting documents are provided to the cashier. The supporting documentation for each voucher is reviewed by the cashier, who then prepares and signs a check in payment of the voucher. For control purposes, a second person, perhaps the treasurer, may also review supporting documents and countersign each check. All supporting documents should be stamped paid or otherwise clearly marked to preclude their reuse to authorize disbursements. The checks are then mailed out together with a copy of the voucher, which serves as a remittance advice. A second copy of the disbursement voucher is filed by voucher number. The supporting documents, including the vendor invoice and, where applicable, the receiving report and purchase order, are attached to the other copy of the disbursement voucher and returned to the accounts payable department for filing in the alphabetical vendor file. The cashier also prepares for each daily batch of checks a journal voucher which reflects the debit to accounts payable and the credit to cash, and which is transmitted to the general ledger clerk. This journal voucher is checked against the batch total prepared by the accounts payable department and is then posted to the general ledger.

The preparation of the bank reconciliation by the internal auditors provides a final control check on the cash disbursements process. All cancelled checks should be examined to ascertain the date of endorsement and name of endorser. All checks paid should be accounted for as either cancelled, outstanding, or voided. For this purpose, of course, checks must be sequentially prenumbered.

Organizational independence with respect to the cash disbursements process is obtained by separation of the recording and authorization functions per-

Voucher No 1623 THE NEEDMORE MANUFACTURING COMPANY
Needmore, Texas

Remit to Avalon Electronics
401 Cherry Street
Waco, Texas 78123

Date entered
5/14/73

Your invoice Date	Your invoice Number	Memo	Invoice Amount	Returns & allowances	Discount	Net remittance

Fig. 16.5 Disbursement voucher.

formed by the accounts payable department and the general ledger clerk from the custodial function of the cashier, under whose authority checks are prepared, signed, and distributed. Other control procedures which reinforce the effectiveness of this separation include: periodic reconciliation of the accounts payable control account balance with the total of the vouchers awaiting payment; the batch total of vouchers due for payment each day, prepared before the vouchers are transmitted to the cashier and checked after all checks have been prepared and mailed against the resulting journal entry; dual signing of the checks; and the preparation of the bank reconciliation.

In many firms it is convenient to be able to make some small cash disbursements in cash rather than by check. In such cases, a petty cash fund may be established from which such disbursements can be made. Use of the "imprest" system for maintaining such funds provides control over the cash disbursed in this manner. Under this system, the amount of the fund is set at some specified amount, such as $100. A petty cash fund custodian is made solely responsible for the fund, and this person should not have any other cash handling or recording functions. The appointed individual must prepare a petty cash voucher for all disbursements made from the fund, and obtain the signature of the payee on each voucher. The fund custodian retains these vouchers so that at any given time the total amount of the vouchers plus the cash remaining in the fund should equal the total amount of the fund. The internal auditor may periodically make surprise counts of the fund to verify this condition.

When the amount of the petty cash fund is low, the fund custodian provides all petty cash vouchers to the accounts payable department. On the basis of these supporting documents, a disbursement voucher is prepared authorizing replenishment of the fund in the exact amount of the total of all the petty cash vouchers. The cashier then prepares and signs a check from this disbursement

voucher to accomplish the replenishment. Petty cash vouchers must be marked paid at this time to prevent their reuse. Furthermore, the cashier should verify the unexpended balance of the fund at this time. The replenishment check should bring the fund balance up to its specified maximum level.

Fixed Assets. The primary procedures and controls in connection with accounting for fixed assets relate to the maintenance of the fixed asset ledger and the acquisition of new assets. In most firms this is a very small job requiring only a few minutes or hours each month. The paid disbursement vouchers and their supporting documentation provide source documents for the origination of asset records in the fixed asset ledger. This ledger is used for preparation and recording of depreciation. It may also be used to record appraisals for insurance purposes.

Control over the fixed assets themselves requires that the serial number and location of each asset be recorded in the fixed asset ledger. All transfers of an asset from one location to another should be authorized and documented, with the resulting documentation serving as a basis for recording such transfers in the fixed asset ledger. Periodically an inventory of fixed assets should be taken and the asset ledger adjusted if necessary. Reconciliation of the asset ledger to the fixed asset control account from time to time is also a necessary control procedure.

For control of fixed assets it is also essential that retirements of fixed assets be approved by a specified individual, and that a system exists to ensure prompt and accurate recording of such retirements. The journal voucher recording a sale or scrapping of an asset must be prepared with reference to the asset ledger to assure proper recording of the gain or loss as well as removal of the cost and accumulated depreciation from the books.

Control procedures for fixed asset acquisition are also essential. Authorization for each asset purchase should be made by a designated manager on the basis of a request form which delineates the cost factors associated with the asset and the reasons for its purchase. Many firms utilize a system whereby asset purchases involving small amounts may be approved by lower level managers, such as the general foreman or director of sales, from their departmental capital expenditure budgets. Larger purchases require approval at higher levels, and very large purchases require the approval of the president and board of directors. Formal capital budgeting analysis, including cash flow projections and discounted present value calculations, should accompany these large proposals. Follow-up reports should be prepared on large projects to evaluate whether the expected results were actually achieved.

General ledger. This function primarily involves posting from journal vouchers to the general ledger accounts. Because the volume of work is typically quite small, this function is often combined with maintenance of the factory overhead ledger, the selling expense ledger, the general and administrative expense ledger, and the fixed asset ledger. Journal vouchers are obtained from many different sources within the accounting department as by-products of almost all

processing of accounting data. The general ledger clerk should check the equality of debits and credits on all journal vouchers prior to posting. At the end of each month, the general ledger clerk prepares and posts accrual and adjusting entries and prepares a post-closing trial balance to check the equality of debits and credits in the general ledger. All control accounts should be reconciled to the subsidiary ledgers at this time. Once any necessary corrections have been made, the closing entries are performed and the monthly financial statements are prepared.

Computer Based Batch Processing Systems

This section describes and illustrates computer based systems for batch processing of (1) cash receipts, (2) cash disbursements and accounts payable debit distribution, (3) fixed asset records, and (4) the general ledger. The systems described use punched card input and maintain all master files on magnetic tape. System flows and controls are emphasized. At the conclusion of the section, a discussion of the integrative impact of the use of disk file storage rather than magnetic tape is presented.

Cash receipts. Procedures for receipt of payments on account in a computer based system would vary from those in a manual system only in that the data processing department would perform the function of posting payments to the accounts instead of the accounts receivable department. A systems flowchart of this process as performed by a data processing department appears in Fig. 16.6. Each day the process begins with assembly of remittances in batches and preparation of batch totals for control purposes by personnel in the mail room. The documents are then transmitted to the input preparation department, where they are keypunched, verified, and sorted into sequence by customer account number. As described in examples in earlier chapters, alternative methods of data preparation are often used, such as key-to-tape encoding or card-to-tape conversion, each followed by sorting of the transaction tape on the central processor.

In many organizations, the remittance advice is a turnaround document — a punched card sent to the customer as a bill or statement with the request that it be returned with the customer's payment. This practice eliminates the necessity for keypunching and verifying the remittance data. In addition, the punched data is generally more accurate on a turnaround document because it is punched automatically as a by-product of computerized billing or statement preparation.

After sorting, the remittance cards are sent to the computer operations department for processing to update the accounts receivable master file. Each remittance is posted to its corresponding master record, and the current account balance in the record is reduced by the amount of the remittance. In addition to the updated version of the accounts receivable master, this run produces: a printout of error transactions and summary information, including batch totals and the summary journal entry debiting cash and crediting accounts receivable;

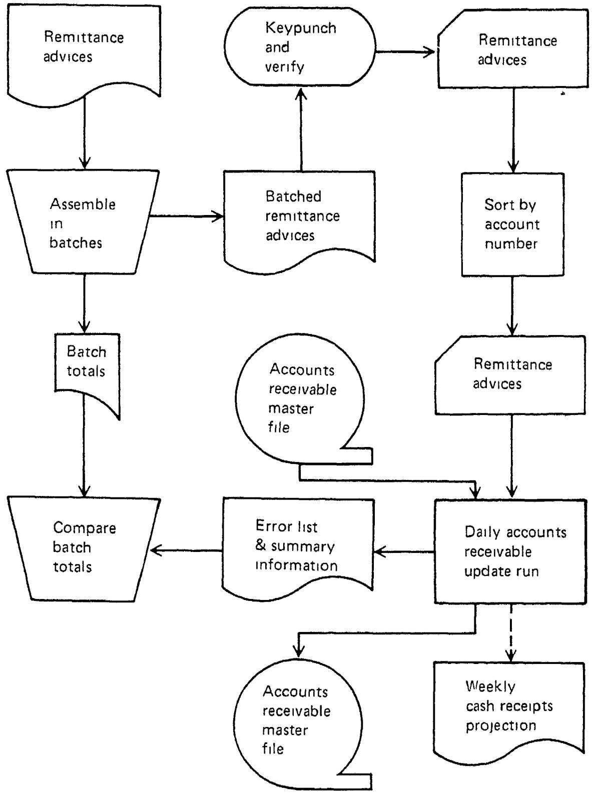

Fig. 16.6 System flow in computerized batch processing of cash receipts.

and a printed report projecting short-term cash inflows resulting from customer payments on account balances due. The latter report, useful to short-term cash management by the treasurer, would probably be generated only once a week, as shown, rather than once a day.

Instituted among internal control procedures in this system shoud be: (1) keyverification of critical data on remittance cards, or alternatively the use of turnaround documents, (2) batch totals including a record count of remittances, a hash total of customer account numbers, and a financial total of remittance amounts; (3) data security provisions with respect to the accounts receivable master file, including the use of internal and external labels, removal of tape file protection ring, application of the grandfather-father-son concept, and use of a tape library with controlled checkout procedures; and (4) an input validation routine in the main update program which performs such edit checks as a sequence check, field checks on all numeric data, validity check on account numbers, and a comparison of the amount remitted with the amount due.

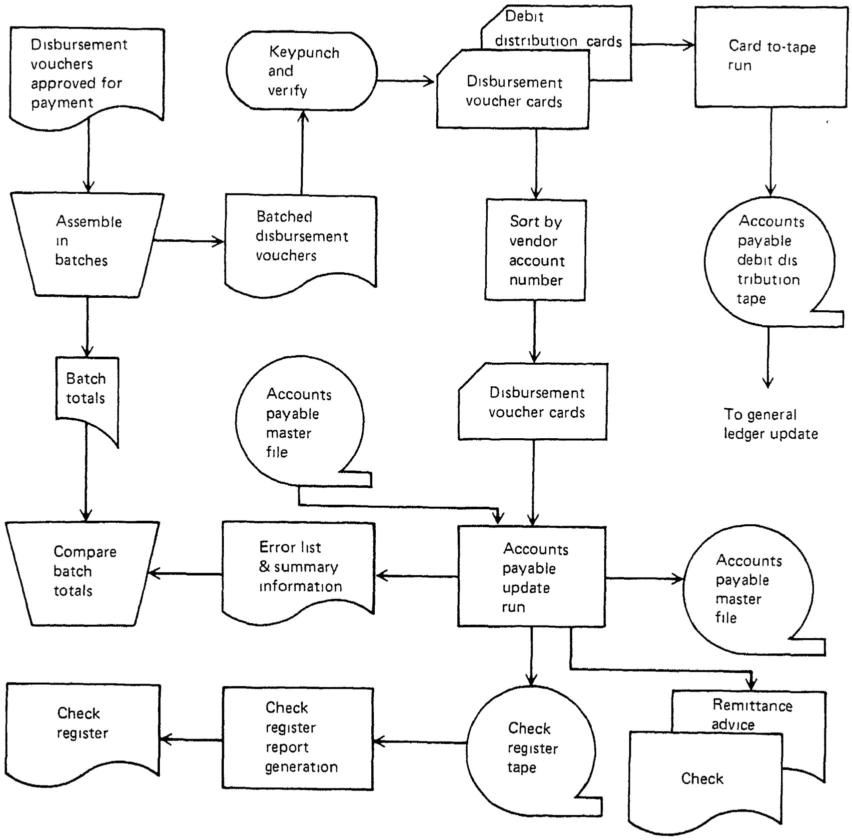

Fig. 16.7 System flow in computerized batch processing of accounts payable.

check register (see Fig. 16.8), which is simply a listing of the check number, amount, vendor, and other relevant data from each check written. The check register provides an audit trail of cash disbursements. In this system, the check register is shown to be recorded on magnetic tape for subsequent conversion to a printed report. The other output of this run is report of error transactions, summary information, and the journal entry debiting accounts payable and crediting cash. The credit to accounts payable originates from the processing of the debit distribution cards mentioned above and described in a subsequent section.

The accounts payable master file may also be used to generate information for short-term cash management. Once each week a routine in the updating program could be triggered to accumulate a summary of total cash flow commitments by week from the accounts payable master. Recall that a similar report may be generated from the open purchase order master file (Fig. 13.9).

CASH DISBURSEMENTS REGISTER

Date: Jan. 11, 1974

Chk. No.	Vendor No.	Vendor Name	Account Payable dr.		Discount cr.		Cash cr.	
1045	63218	National Supply	$ 512	67	$ 10	25	$ 502	42
1046	17641	Ross Mfg.	$ 95	07	$	95	$ 94	12
1047	41524	Northern Metal Prod.	$ 742	72	$ 14	85	$ 727	87
1048	36602	Webster Bros.	$4,208	18	$ 84	16	$4,124	02

Fig. 16.8 Cash disbursements register.

This report might be included in the summary information for the run, and detached for transmittal to the treasurer.

In addition to the use of batch totals and the keyverification of critical data punched from the disbursement vouchers, control procedures in this system center around data security provisions with respect to the accounts payable master tape, an input validation routine in the accounts payable update program, and proper disposition of the printout of error transactions and batch totals. The specifics of application of these procedures should by now be familiar to the reader and are not elaborated upon here.

Fixed assets. A systems flowchart of monthly batch processing of fixed asset records by computer appears in Fig. 16.9. Fixed asset transactions are of several different types, and may be recorded on various types of source documents. These transactions include new asset purchases, sales or scrappings of existing assets, location transfers, revisions to estimated useful life, major additions or writedowns, and several other kinds of adjustments. Even then, the monthly volume of these transactions is usually not great, and so it is assumed in the illustration that only one set of batch totals is prepared. Among the batch totals prepared would be a record count of the total number of transactions, record counts of the number of transactions of each type, a hash total of asset numbers, and a financial total of new asset purchases and other transactions affecting the dollar balance of the ledger records.

After batch totals are prepared, the fixed asset transactions are keypunched and verified, and the cards are sorted by asset number for processing to update the fixed asset ledger. This main updating program must be written to identify the transaction code of each record and carry out the appropriate steps for each type of transaction. One output of this monthly run is simply a report listing the contents of the file for reference purposes. Another output is a tape listing of all depreciation charges and the overhead or expense ac-

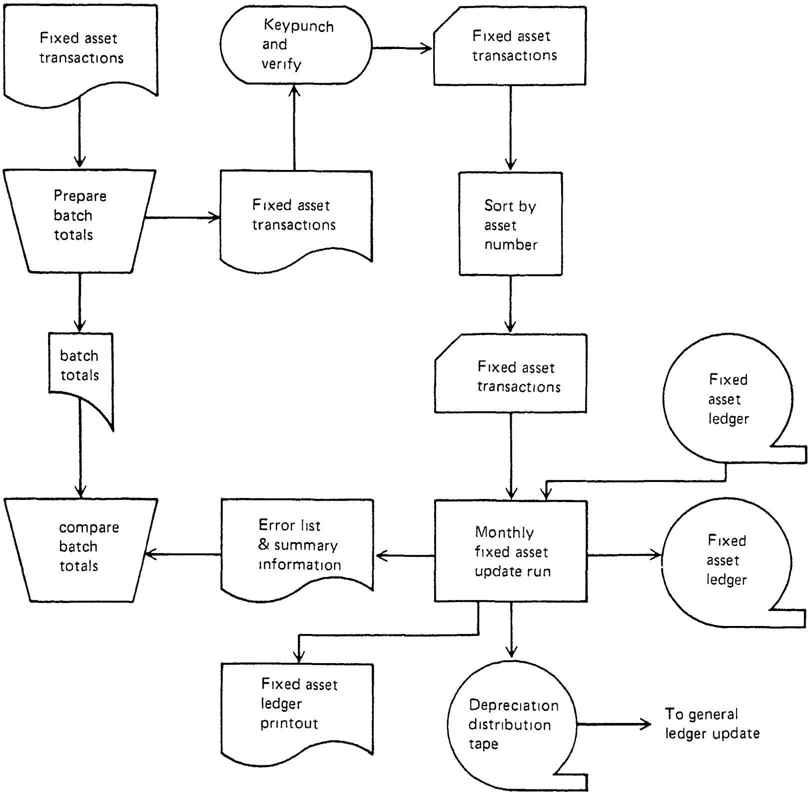

Fig. 16.9 Computerized batch processing of fixed asset records.

count to which each is charged. This tape is sorted by account number and processed to update the general ledger in an operation described in the next section. The other outputs are the updated fixed asset master on magnetic tape and a report listing error transactions and summary information, including batch totals and summary journal entry. If new asset purchases are recorded in the accounts payable debit distribution, this summary entry will record only the effects of such asset transactions as sales, writeoffs, or writedowns.

The batch totals on the summary printout must be compared to those accumulated prior to processing, and any errors revealed by this comparison or the error listing should be traced to their cause, corrected, and resubmitted to the system. Other internal control procedures in this system include keyverification of critical data on each transaction, data security provisions with respect to the fixed asset ledger tape, and an input validation routine in the fixed asset update program. The input validation routine could be quite cum-

bersome in this program, since a different set of edit checks must be used on each type of transaction, and there are a large variety of transaction types.

General ledger. In the manual system described earlier in this chapter, it is assumed that subsidiary ledgers for manufacturing overhead, selling expenses, and general and administrative expenses are maintained separately from the general ledger. This is done primarily for convenience and to permit clerical specialization. However, in a computerized system, integration of these subsidiary ledgers with the general ledger provides greater advantages than maintaining them separately. The system described in this section therefore assumes that the general ledger contains all of the detailed cost and expense accounts.

The computerized general ledger may be updated several times during a month. The systems flow of this updating process, illustrated in Fig. 16.10, is actually a composite of updating processes which take place at different times and frequencies during a month. The accounts payable debit distribution tape, prepared as a by-product of daily input preparation for accounts payable processing (see Fig. 16.7), would be processed against the general ledger each day. The payroll distribution tape, a product of the processing of indirect factory labor and office payrolls, would be processed subsequent to each payroll operation, which might be weekly, biweekly, or monthly. The depreciation distribution tape, an output of fixed asset processing (see Fig. 16.9) would be processed once a month following the fixed asset update run. Other entries include summary entries from various daily or weekly batch processes, which should be posted as they occur, and end-of-month accrual, adjusting, and miscellaneous entries. Once each week, or perhaps more or less frequently, a printout of the general ledger is obtained for reference.

At the end of each month, the master budget is processed with the final monthly version of the general ledger to prepare various financial reports. It is assumed that both of these tapes are sequenced by department number, which is the major key within the account number. This run generates departmental performance reports comparing actual and budgeted cost for all production departments, factory service departments, and selling and administrative units within the organization. An example of such a report is illustrated in Fig. 16.11. Reports aggregating these financial data for summarization of the performance of higher level managers cannot be printed in the same pass, but may be recorded on tape for subsequent printing. As an example, the financial statements, which aggregate data from all departments according to account codes, are shown to be recorded on tape as an output of this run, after which this tape is processed to print a report comparing projected and actual financial results. In addition to generating these various reports, the run closes all revenue and expense account balances to the retained earnings account and prepares a beginning general ledger for the next period.

Disk files. All of the processes described above could be simplified and integrated if disk file storage were used in place of magnetic tape. For example,

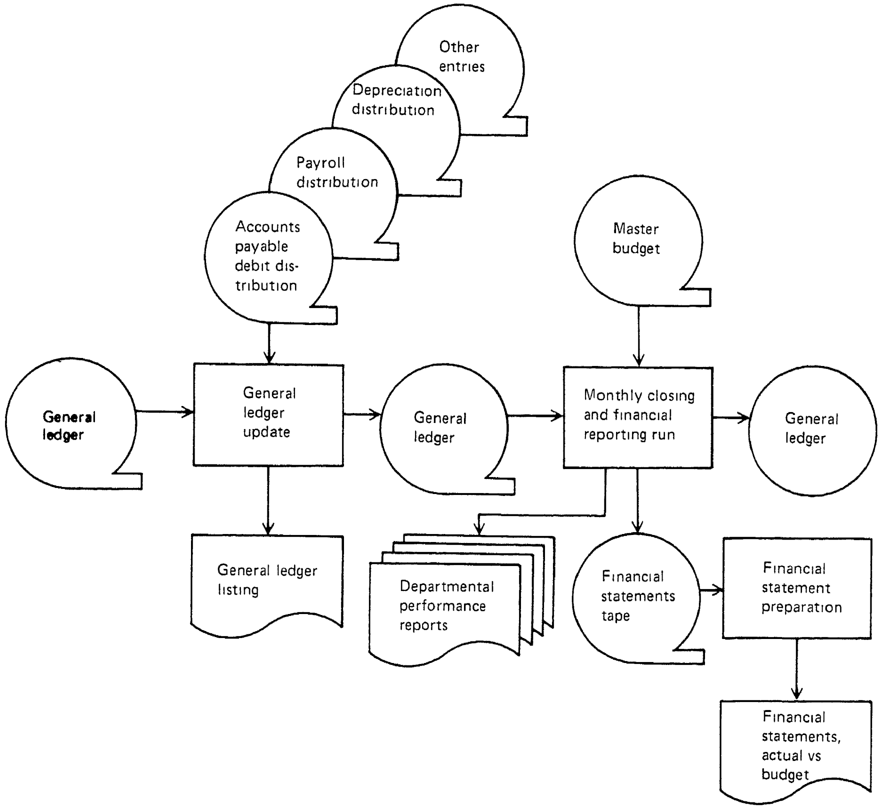

Fig. 16.10 Systems flow in general ledger updating and financial reporting.

if the general ledger were maintained on disk, most journal entries could be posted directly to the appropriate ledger accounts upon completion of processing of batches of accounting transactions. To use the processing of cash receipts as an example, the run illustrated in Fig. 16.6 accumulates a summary journal entry debiting cash and crediting the accounts receivable control account. With the general ledger on disk, these two ledger accounts could be accessed directly once the entire batch of cash receipts had been processed, and the summary entry could be posted at that time. This same approach could be used to post summary journal entries resulting from the billing process, raw materials inventory updating, labor and materials costing, payroll processing, finished goods inventory updating, cash disbursements processing, fixed asset updating and depreciation calculation, and so forth. Under this system, the only transactions posted to the general ledger accounts in batches would be the daily accounts payable debit distribution, and the end-of-month accrual, adjusting and closing entries.

OPERATING PERFORMANCE SUMMARY						
Department ≠ 473 Machining					Foreman Oscar Nagursky	
Cost element	Month ending 2/28/74			Year to date		
	Budget	Actual	Over (under) budget	Budget	Actual	Over (under) budget
Controllable overhead						
Indirect labor	$4,750	$4,608	$(142)	$9,300	$9,248	$(52)
Idle time	250	304	54	480	502	22
Tools and supplies	880	856	(24)	1,720	1,702	(18)
Maintenance	750	802	52	1,450	1,638	188
Rework	120	70	(50)	230	180	(50)
Miscellaneous	200	230	30	380	370	(10)
Total controllable overhead	$6,950	$6,870	$(80)	$13,560	$13,640	$80
Direct labor	$13,200	$13,256	$56	$26,000	$26,384	$384

Fig. 16.11 Cost performance report for a production department.

Several other efficiencies could be achieved if disk files and online terminals were used in the accounting information system. For example, if the general ledger and fixed asset ledger were maintained on disk, the data in these files could be accessed when needed, thereby eliminating the need for periodic printouts of their entire contents. Similarly, summary reports such as the cash receipts projection based upon the accounts receivable master, and the cash disbursements projection based upon the accounts payable master could be generated upon request from an online terminal rather than periodically printed. In this way the availability of this information is made to correspond directly to needs for it. Another efficiency made possible by the use of disk files is the use of spooling in all processes which generate more than one printed output, such as the accounts payable updating run shown in Fig. 16.7.

As a result of the use of disk files in the ways described, numerous tape handling operations and tape sorting runs could be eliminated. In addition, several printing operations and related report handling and distribution steps would be eliminated. Disk file storage can therefore provide significant savings of processing time and cost in financial information processing.

Possible Real-Time Applications

The processing of financial information is not a common area for application of real-time systems. This is true generally because decisions involving financial

information do not require great speed. Perhaps the reason for this is that financial events are more predictable than events involving production or marketing. Therefore, careful planning can be accomplished so that decisions can be effectively made in advance of events rather than immediately as events occur.

One possibly useful application of real-time systems to financial information involves inquiry processing. An online financial information system would enable immediate response to inquiries concerning comparisons of current expenditures with budgeted expenditures, up-to-date calculations of profit center contribution, or information required for audit investigations. Whether such responses would be needed immediately for effective decision making is another question.

As business organizations complete the implementation of real-time systems in the areas of marketing and production, it may then be realized that conversion of the financial information system to real-time capability involves relatively little additional cost. The main costs would be for a small number of additional terminals, and for additional application programs. As discussed in Chapter 7, conversion from batch processing to real-time computer systems may also generate significant cost savings and other benefits. Cash receipts and disbursements would be the most significant areas of conversion in terms of volume of processing. Except for a small number of adjusting entries, maintenance of the general ledger and the cost and expense ledgers could be completely automated. The volume of operator initiated entries to the fixed asset system would also be relatively insignificant.

If cash receipts processing is converted to an online basis, the keypunching of receipts cards is replaced by the keying of receipts data into a terminal. Such a system would make the accounts receivable records only slightly more current than a batch processing system operating on a daily cycle. Similarly, conversion of cash disbursements processing to an online basis involves replacement of the keypunching of disbursement voucher cards and debit distribution cards by the keying of this data into a terminal. This system also fails to add much to the currency of payables and ledger account data. However, in both of these cases, savings would result from online verification of input data and from elimination of keypunching, verification, sorting, and batch input operations.

One application of real-time systems to financial management which has great potential is the area of mathematical models for financial planning. Such models enable managers to experiment with alternative decisions or policies which are under consideration, with the model predicting the financial outcome of each alternative. The primary advantage of immediate response in a system of this sort is the capability of interaction with the model which is available to the system user. That is, upon receipt of a system response to a user experiment, the user may formulate a second experiment based upon the results of the first. This process may be continued through a series of many

experiments. The real-time capability of the system therefore generates considerable savings in timeliness of information over the use of batch processing, in which each experiment in a series would require a separate computer run. As the manager formulates and test possible decision alternatives, he receives continuous feedback from the model which guides his subsequent formulations. This process of interaction of the manager with the system enhances considerably the usefulness of both the system and the model.[3]

REVIEW QUESTIONS

1. Describe an example of an organization structure for the financial management function in a typical business organization. What are the primary decision responsibilities and information requirements of the financial management function?
2. What accounting journal entries summarize the data processing activities involved in
   a) cash receipts,
   b) cash disbursements,
   c) recording of overhead costs,
   d) recording of expenses,
   e) maintenance of fixed asset records, and
   f) financial statement preparation at the end of a month?
3. Describe the content and usage of several master files involved in the processing of financial information.
4. Describe the basic format of all accounting ledger records.
5. What should be the relationship between a general ledger control account and its corresponding subsidiary ledger?
6. List several classification categories for which digit positions may be provided in a chart of accounts coding system.
7. What departments in a business organization might typically be involved in the manual processing (a) of cash receipts, and (b) of cash disbursements? In both cases what documents might be used and what reports generated? What data or information would each document or report contain? In what department would each document or report originate, and where and for what purpose would each be distributed?
8. What control procedures might be used in manual processing of receipts of payments on account? How is organizational independence achieved with respect to this process?
9. What is a remittance advice and what functions does it serve?
10. What procedures might a retail organization establish to record and control cash sales?

[3] For further discussion of financial planning models, see George W. Gershefski, *The Development and Application of a Corporate Financial Model* (Oxford, Ohio: The Planning Executives Institute, 1968).

11. What means of automating the recording of transactions are available to retail organizations?
12. What control procedures might be used in manual processing of cash disbursements in a typical business organization? How is organizational independence achieved with respect to this process?
13. What is a disbursement voucher and what functions does it serve?
14. Describe the imprest petty cash system. Indicate in your description the most significant control procedures in the system.
15. Describe procedures and controls in manual systems in a typical business organization for maintenance of (a) fixed asset records, and (b) the general ledger.
16. Describe the similarities and differences in data flows and departmental functions between manual systems and computerized systems for processing of receipts of payments on accounts.
17. Describe and illustrate, using a systems flowchart, a computer based batch processing system for processing of cash receipts. Describe several control policies and procedures appropriate for such a system.
18. Describe the similarities and differences in data flows and departmental functions between manual systems and computerized systems for processing cash disbursements.
19. Describe and illustrate, using a systems flowchart, a computer based batch processing system for processing of cash disbursements. Describe several control policies and procedures appropriate for such a system.
20. Describe and illustrate, using a systems flowchart a computer based batch processing system for maintaining fixed asset records. Describe several control policies and procedures appropriate for such a system.
21. Describe the differences in operations between a computerized accounting system in which the general ledger is maintained on magnetic tape and one in which it is maintained on magnetic disk.
22. Describe several ways in which computerized batch processing of financial information can be simplified by the use of magnetic disk file storage instead of magnetic tape.
23. Why is the processing of financial information not a common area for application of real-time computer systems?
24. Describe the nature and possible uses of real-time systems for processing of financial information in a typical business organization.

DISCUSSION QUESTIONS

25. Cite as many examples as you can of information processing interfaces (or interactions) between two or more of the marketing, logistics, personnel, and financial information subsystems of a typical business organization.
26. Discuss the similarities and differences in the functions of a Treasurer and a Controller. Is there a need for both of these functional specializations to exist within a typical business organization, or could one executive effectively fill both roles?
27. Discuss the usefulness of incorporating a real-time capability into a mathematical modeling system used for financial planning.

PROBLEMS AND CASES

28. Describe appropriate controls in a procedure for processing receipts of payments on account which would provide the best protection against the following contingencies.
    a) Theft of checks received through the mail by personnel in the mail room.
    b) An undetected error in posting from remittance advices to the accounts receivable ledger.
    c) Theft of funds by a cashier who, instead of endorsing checks received for deposit, cashes them and keeps the cash without recording its receipt.
    d) Covering up of defalcations of checks received by adjustments of the accounts receivable ledger.
    e) Theft of cash by sales personnel in a retail organization, covered up by failure to record cash sales.
29. Describe appropriate controls in a procedure for maintaining fixed asset records which would provide the best protection against the following contingencies.
    a) Acquisition of a fixed asset for which no worthwhile use exists within the firm.
    b) A plant foreman reports that an asset in his department has been scrapped, when actually he had it removed and delivered to his own home.
    c) A large overstatement of the fixed asset control account after several errors are made in updating the account over a period of years.
    d) Inaccurate charging of depreciation to departments because several items of equipment are no longer located in the departments for which they were originally acquired.
30. Describe appropriate internal controls in a cash disbursements procedure which would protect against the following contingencies.

a) An employee writing a check to himself or to a fictitious company.
b) A large overstatement of the accounts payable control account due to several errors made in posting to the account over a period of time.
c) Payment of a fictitious invoice for goods which were never delivered.
d) Issuance of two checks in payment of two different copies of the same vendor invoice.
e) Overpayment of a vendor due to errors in the calculation of extensions on the vendor's invoice.
f) Overpayment of a vendor due to the use of inaccurate item prices on a vendor invoice.
g) "Borrowing" of a portion of the petty cash fund for personal use by the fund custodian.

31. Cash receipts in the Whirlaway Company are processed in the following manner. The cashier opens all mail containing customer payments and prepares a batch control tape of the total amount received which is sent to the general ledger clerk to support the appropriate journal entry. The cashier prepares two copies of a deposit slip, deposits the cash receipts in the bank, and files the bank-validated copy of the deposit slip by date. He also sends the remittance advices to the accounts receivable clerk, where they are posted to customer accounts.

    Assume that no other operations or personnel are involved in the processing of cash receipts. Prepare a document flowchart of the processing described above. Then identify several (at least three) deficiencies in internal control of the process, and for each deficiency describe an error, manipulation, or inefficiencey which could occur as a result.

32. The United Charities organization in your town has engaged you to examine its statement of receipts and disbursements. United Charities solicits contributions from local donors and then apportions the contributions among local charitable organizations.

    The officers and directors are local bankers, professional men, and other leaders of the community. A cashier and a clerk are the only full-time salaried employees. The only records maintained by the organization are a cashbook and a checkbook. The directors prefer not to have a system of pledges.

    Contributions are solicited by a number of volunteer workers. The workers are not restricted as to the area of their solicitation and may work among their friends, neighbors, coworkers, etc., as is convenient for them. To assure blanket coverage of the town, new volunteer workers are welcomed.

    Contributions are in the form of cash or checks. They are received by United Charities from the solicitors, who personally deliver the contributions they have collected, or directly from the donors by mail or by personal delivery.

The solicitors complete official receipts which they give to the donors when they receive contributions. These official receipts have attached stubs which the solicitors fill in with the names of the donors and the amounts of the contributions. The solicitors turn in the stubs with the contributions to the cashier. No control is maintained over the number of blank receipts given to the solicitors or the number of receipts stubs turned in with the contributions.

Discuss the control procedures you would recommend for greater assurance that all contributions received by the solicitors are turned over to the organization. (Do not discuss the control of the funds in the organization's office.)[4]

33. You are auditing the Alaska Branch of Far Distributing Co. This branch has substantial annual sales which are billed and collected locally. As a part of your audit, you find that the procedures for handling cash receipts are as follows:

Cash collections on over-the-counter sales and C.O.D. sales are received from the customer or delivery service by the cashier. Upon receipt of cash, the cashier stamps the sales ticket "paid" and files a copy for future reference. The only record of C.O.D. sales is a copy of the sales ticket which is given to the cashier to hold until the cash is received from the delivery service.

Mail is opened by the secretary to the credit manager and remittances are given to the credit manager for his review. The credit manager then places the remittances in a tray on the cashier's desk. At the daily deposit cut-off time the cashier delivers the checks and cash on hand to the assistant credit manager who prepares remittance lists and makes up the bank deposit which he also takes to the bank. The assistant credit manager also posts remittances to the accounts receivable ledger cards and verifies the cash discount allowable.

You also ascertain that the credit manager obtains approval from the executive office at Far Distributing Co., located in Chicago, to write off uncollectable accounts, and that he has retained in his custody as of the end of the fiscal year some remittances that were received on various days during the last month.

Required:

a) Describe the irregularities that might occur under the procedures now in effect for handling cash collections and remittances.
b) Give procedures that you would recommend to strengthen internal control over cash collections and remittances.[5]

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[4]Question 3, Auditing Section, American Institute of Certified Public Accountants Examination, November 1963. Copyright © 1963 by the American Institute of Certified Public Accountants and reprinted with permission.

[5]Question 1, Auditing Section, American Institute of Certified Public Accountants Examination, Novermber 1962. Copyright © 1962 by the American Institute of Certified Public Accountants and reprinted with permission.

34. The collection functions of the Robinson Company, a small paint manufacturer, are attended to by a receptionist, an accounts receivable clerk, and a cashier who also serves as a secretary. The company's paint products are sold to wholesalers and retail stores.

    The following describes all of the procedures performed by the employees of the Robinson Company pertaining to collections:

    Since the Robinson Company is short of cash, the deposit of receipts is expedited. The receptionist turns over all mail receipts and related correspondence to the accounts receivable clerk who examines the checks and determines that the accompanying vouchers or correspondence contains enough detail to permit posting of the accounts. The accounts receivable clerk then endorses the checks and gives them to the cashier who prepares the daily deposit. No currency is received in the mail and no paint is sold over the counter at the factory.

    The accounts receivable clerk uses the vouchers or correspondence that accompanied the checks to post the accounts receivable ledger cards. The bookkeeping machine prepares a cash receipts register as a carbon copy of the postings. Monthly the general ledger clerk summarizes the cash receipts register for posting to the general ledger accounts. The accounts receivable clerk also corresponds with customers about unauthorized deductions for discounts, freight or advertising allowances, returns, etc., and prepares the appropriate credit memos. Disputed items of large amount are turned over to the sales manager for settlement. Each month the accounts receivable clerk prepares a trial balance of the open accounts receivable and compares the resultant total with the general ledger control account for accounts receivable.

    Required:

    Discuss the internal control weaknesses in the Robinson Company's procedures related to customer remittances and the accounting for these transactions. In your discussion, in addition to identifying the weaknesses, explain what could happen as a result of each weakness.[6]

35. The Rock Island Brewery has recently acquired a new disk memory device. Previously all files maintained by the company's computerized data processing center had been on magnetic tape.

    You are involved in designing a computer application that will process disbursement vouchers which have been approved for payment and keypunched onto cards. The voucher cards will be sorted on a card sorter and processed to update both an accounts payable master file and a general ledger file. One of these two master files is to be maintained on the disk unit, the other on tape. Output of this processing run will include

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[6]Adapted from Question 4, Auditing Section, American Institute of Certified Public Accountants Examination, May 1965, Copyright © 1965 by the American Institute of Certified Public Accountants and reprinted with permission.

the updated versions of the two master files, a printed report containing error transactions and summary information, and a disbursements tape listing all voucher records for which payment is due. The disbursements tape is processed to generate (1) a remittance advice and check in payment of each voucher on the tape, and (2) a disbursements register, which is simply a printed list of all checks paid.

a) Assume the general ledger file will be maintained on the disk. Prepare a systems flowchart of the operations described above.
b) What is the minimum hardware configuration required to perform the above processes after the voucher cards have been keypunched and keyverified? (Assume no spooling.)
c) What are the advantages of storing the general ledger file on the disk unit? of storing the accounts payable file on the disk unit?

36. The Darwin Department Store maintains its customer accounts by computer. Once each day all receipts of payments on account are processed to update an accounts receivable master file maintained on a disk storage unit. All nonroutine file changes and other adjustments to the accounts receivable master are also processed at the same time. All of the input data records are keypunched, after which the punched cards are processed by a utility routine to transfer their contents to magnetic tape. The records on tape are then sorted and processed sequentially to update the accounts receivable master. The tape sort requires four tape drives. Output of the updating run includes (1) a printed report listing error transactions and summary information, and (2) a printed report listing the records of all past due accounts.

Required:

a) What data should be included on each cash receipt input record?
b) Give two specific examples of the "nonroutine file changes and other adjustments" mentioned above.
c) Prepare a systems flowchart of all computer processes described above.
d) List the components of the hardware configuration necessary to accomplish all phases of the processing described in the case subsequent to keypunching. (Assume no spooling.)
e) Describe a comprehensive set of control policies and procedures for this accounts receivable application. For each policy or procedure, indicate the objective and exactly the method of operation. Be sure to relate each policy or procedure specifically to the accounts receivable processing system described above.

37. The Able Manufacturing Company maintains a master budget file on magnetic tape. At the end of each month this file is processed by computer together with a manufacturing overhead ledger, also maintained on

magnetic tape, to generate performance reports for all production departments. The format of each such report is identical to that shown in Fig. 16.11, except that direct labor costs are not included in the report.

The budgeted amount of each cost element for the current month is computed as $(a + bx)$, where a is the fixed amount of that cost element per month, b is the variable rate of that cost element per month, and x is the value of the base to which the variable rate is applied. The rate base for each cost element is one of three different rate bases used, which are direct labor cost, direct labor hours, and machine hours. The value of each of these three bases for the current month are entered into the system at the beginning of processing.

Required:

What specific data elements must be included in each overhead cost record of (a) the master budget, and (b) the manufacturing overhead ledger, in order for these files to be used as described above in generating performance reports for production departments?

38. Culp Electronics Company processes disbursement authorizations online as vendor invoices are matched with receiving reports, purchase orders, and other supporting documents in the accounting department. Each disbursement authorization is entered via a data terminal and processed to update the accounts payable master file. The debit portion of the entry is processed to update either (1) the inventory ledger, (2) the expense ledger, or (3) the fixed asset ledger, depending on what the disbursement is for.

For each disbursement authorization relating to an inventory purchase, the following data are entered: the vendor account number; amount due; discount rate; due date; and, for each item purchased, the part number, price, and quantity.

Required:

Consider only disbursement authorizations relating to inventory purchases as described. Describe several means by which the system could be programmed to check the accuracy and validity of the input data. Relate your answer specifically to the data items mentioned above.

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